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BENJAMIN SILLIMAN.

BENJAMIN SILLIMAN, son of Benjamin Silliman the founder of this Journal, and long one of its editors, died at New Haven, Connecticut, on the fourteenth of January, 1885.

Mr. Silliman was born in New Haven, on the fourth of December, 1816. His mother, Harriet Trumbull, was the daughter of Jonathan Trumbull, Governor of the State of Connecticut from 1798 to 1809. Surrounded from his childhood by an atmosphere of science, he early made acquisitions in chemistry and mineralogy, and exhibited also much interest in the practical arts and mechanics. He entered Yale College in August, 1833, and was graduated four years later, with the class of 1837, a class which included an unusual number of men who have since had prominent positions in the country. Before graduation, in the summer of 1836, he began his mining explorations in a visit with his father to the gold region of Virginia, a report on which, over thirty pages in length, by his father, is contained in volume xxxii of this Journal.

After leaving college, in 1837, he became his father's assistant in chemistry and his other departments, a position just then left vacant by the resignation of Mr. J. D. Dana, who had received an appointment to the department of Geology and Mineralogy in the Wilkes Exploring Expedition.

The Laboratory gave him opportunities for experiment and study of which he assiduously availed himself; and by the year 1842 he had, without outside help, of which the country afforded then almost nothing, acquired sufficient knowledge of general and analytical chemistry and mineralogy to enable him to instruct others on these subjects, and he received a few students in what would now be called very narrow quarters in the old laboratory of the college. One of the earliest of these private pupils was Mr. John P. Norton, afterward Mr. Silliman's associate, who studied with him in 1842 and 1843, and later spent two years in laboratories in Edinburgh and Utrecht. Another was Mr. T. Sterry Hunt, who commenced his studies with Mr. Silliman in 1845,—then a young man of 20 years, having some knowledge of chemistry and a zeal for science, which he brought with him from his home in Norwich (Connecticut), that commended him strongly to both the Sillimans.

This was the commencement of work in advanced chemistry in the College; but it was outside of the College curriculum and had no recognition from the College authorities. In 1846 a memoir to the Corporation by himself, adopted and seconded by his father, urging the official recognition and organization of a new department of advanced science, led to the establishment of the "Department of Philosophy and the Arts." The "School of Applied Chemistry" was organized under this department, and placed in the charge of Mr. Silliman, as Professor of Chemistry applied to the Arts, and Mr. John P. Norton, as Professor of Agricultural Chemistry. The school took possession of the old Presidential residence on the college ground, which the professors, without salaries from the college,

and at their own expense, fitted up for the purpose—by the permission of College authorities, but without the privilege of using the building free of rent. Thus Mr. Silliman, through his zeal and energy, early made a strong impression on the system of education at Yale; and the College had, almost unknowingly to itself, taken an important step toward the rank and character of a university.

The School was successful from the beginning, and the enthusiasm of the professors called out equal enthusiasm in the pupils. It was the germ from which proceeded later, under an enlarged faculty—though still an unpaid self-sacrificing faculty—the Yale Scientific School; and this prepared the way for the greater expansion under the generous gifts of Mr. Sheffield. Among the six students of the year 1847, the first after the new organization, were three, G. J. Brush, S. W. Johnson and Wm. H. Brewer, who later became professors in the Yale Scientific School, and are still in active service. Mr. Silliman's connection with the Scientific School continued until 1869, but his instruction was interrupted by his residence in Louisville mentioned below, and to a greater or less degree after his return to New Haven by duties in other directions.

In 1838, Mr. Silliman became associated with his father in the editorship of the American Journal of Science and Arts, the Journal then in its 21st year and Mr. Silliman in his 22nd. This arrangement continued until the close of 1845, when the first series of fifty volumes was ended, after which Mr. James D. Dana was associated with Mr. Silliman in the editorial duties. Up to the present time, 1885, his name has stood among those of the editors of the Journal now for nearly half a century.

In the winter of 1845-46, Mr. Silliman gave a course of lectures on Agricultural Chemistry in New Orleans upon the invitation of leading commercial and professional men in that city. In 1849 he received the appointment of Professor of

Medical Chemistry and Toxicology in the Medical College at Louisville, Kentucky, which chair he occupied for five years. Louisville became for the time his place of residence. He relinquished this position in 1854 to enter upon instruction in the Academic and Medical departments of Yale College, his father's resignation having left the place vacant. His position as Professor in General and Applied Chemistry in the Academic College he resigned in 1870, but retained his connection with the Medical School until his death.

In 1851 Mr. Silliman accompanied his father on the latter's second visit to Europe. During the time abroad the party visited England and from there traveled through France to Italy and Sicily. On the return some time was spent in Switzerland and Germany. The journey was a profitable one in many ways. The former European tour of his father, in 1805–6, had been cut short by war which compelled a speedy retreat after a brief time in Holland, and it was a special delight to him now to visit regions of volcanoes and glaciers, which had been subjects of eloquent lectures by him for so many years, and to see face to face the men whose names he had so often quoted, and so long honored—Lyell and Murchison in England, Brongniart, Milne-Edwards and Élie de Beaumont in Paris, Marignac and De la Rive in Geneva, Humboldt, Rose, Liebig and others in Germany; and in this pleasure his son shared most profoundly.

In 1853 Mr. Silliman had charge of the Chemical, Mineralogical and Geological department of the Crystal Palace in New York. At this time he edited, in connection with Mr. Charles R. Goodrich, a large illustrated quarto volume entitled the "World of Science, Art and Industry;" and, in 1854, another similar volume entitled "The Progress of Science and Mechanism."

In March, 1864, he made his first visit to California, where, for about a year, he was engaged in the professional work of

examining and reporting on mines. His mining explorations at this time were extended into Arizona; and one of the volumes of this Journal for 1866, contains an account by him of his trip to the Mojave desert, Fort Mojave and the San Francisco Mining district. This visit covered the period of his father's death at New Haven which occurred in November of that year. A second visit to the Pacific States, for a similar purpose, was made by him in the year 1867, and still another in 1872; and after 1872, his journeyings as a mining expert carried him over nearly all the rest of the Rocky Mountain region within the limits of the United States.

Mr. Silliman's scientific publications are numerous and cover a wide field. In 1846, his father's work on chemistry having been long out of print, he published his "First Principles of Chemistry." The work had many excellent features, was highly valued in the country and met with great success, more than fifty thousand copies of the three editions (1846–1853) having been sold. In the part of the work on Organic Chemistry he had the assistance of Dr. T. Sterry Hunt. About ten years later, in 1858, appeared another work, of somewhat similar nature, entitled the "First Principles of Physics or Natural Philosophy;" a second edition of it was published in 1860. For the work the author modestly claimed, in his Preface, only the credit that "belongs to a faithful digest and compilation from the best authorities in modern science." The volume contained a vast amount of matter, well arranged for instruction, and for many years it was the best known of Physical textbooks in the country.

Mr. Silliman's papers in this Journal are more than fifty in number, and embrace a wide range of subjects. The larger part are descriptions of minerals, more especially from the chemical side, and among the papers are many of prominent interest: on the composition of Calcareous Corals (1846); on the new species, Emerald Nickel, from Texas, Pa. (1847); the

results of the optical examination of the Micas (1850); on Gay-Lussite from near Ragtown, Nevada (1866), in which the occurrence of this mineral in process of formation is described; on Priceite a new borate of lime (1873); on Platinum and Iridosmine at the Cherokee Gold Mine, California (1873); Tellurium ores of Colorado (1874); on the occurrence of Gold with scheelite in Idaho (1877); on Jarosite in Arizona (1879); on Vanadates, Chromates and Tungstates in Arizona (1881); on the Iron Mountain of Durango, Mexico (1882).

In the department of mineralogy he always took an active interest. His opportunities for collection were large and he accumulated a fine cabinet which, in 1868, was sold to Cornell University, where it bears the name of the Silliman Cabinet. The mineralogical collections of Yale College are indebted to him for various gifts; and through his personal solicitation of funds the Baron Lederer Collection was secured, in 1843, for the college.

Other papers by him relate to meteoric stones and irons, as those of Burlington, N. Y., Lockport, N. Y., of Texas, of Concord, N. H., Shingle Springs, Cal.; points in geology and physical optics; photographic experiments with the voltaic arc, then a matter of novelty; the illuminating powers of gas, etc.

Professor Silliman delivered one of the addresses on the occasion of the celebration of the Centennial of Chemistry at Northumberland, Pennsylvania in August, 1874, which took the form of a full list of American Contributions to Chemistry up to the date of the meeting; it extended to one hundred and seventy-six pages and is a valuable historical work, the result of a vast amount of labor. It contains a complete list of his own papers up to the time of publication.

Mr. Silliman, throughout his life, but especially in the last twenty years, gave a large part of his energies to work in applied science, including the examination of mines, the prep-

aration of reports on questions connected with the chemical arts and manufactures, in which subjects his knowledge was remarkably extensive, expert testimony in courts, and other matters of practical interest. His reports on these subjects have been very numerous and involved a great amount of work. One of the latest and most important, was the report to the National Academy of Sciences, as chairman of a committee appointed by them, on the subject of the use of Sorghum as a source of sugar. His position as State Chemist, to which he was appointed in 1869, also gave him much to do in the line of applied chemistry.

Professor Silliman took a personal interest in the municipal affairs of the town of New Haven, and in his early life, between 1845 and 1849, he was a member of the Common Council. He was one of the fifty original members of the National Academy of Sciences, incorporated by Congress in 1863. He was also a member of a number of other Scientific Societies at home and abroad.

Professor Silliman was a man of exceedingly generous nature and kindly disposition. He was ever cheerful, ever inclined to look upon the bright side of life, hopeful and sanguine of success where others might be discouraged; and if his expectations for himself and others were not always realized, it was largely owing to this element in his character. In society he was most genial, abounding in conversation based on a remarkable range of information on general topics and with anecdote ready for the entertainment of his guests. Hospitality to friends of the College or to men of science or to those of his own kin and personal intimacy was his delight, and to this some of those present at the recent meeting of the British Association can testify.

During the greater part of his life Mr. Silliman enjoyed excellent health. He had much more than the ordinary amount of vigor, and rarely felt the necessity of considering whether

he were able to undertake any labor proposed to him or not. Four years since, after an excursion, late in the autumn of 1880 among the mountains of Pennsylvania, he was prostrated for some weeks with heart disease; and it seemed to his friends for awhile that at the best his days of active work were at an end. But in the course of another six months he was off to New Mexico on a visit to the Negretta Mountains (Black Range) in Socorro County; and he returned from the elevated mountain region apparently uninjured by the trip, though conscious of a weakened constitution. His energy was far from giving out; and other excursions were undertaken in the course of the following years, including another trip to New Mexico. His recent illness commenced in October last, with a severe return of his heart complaint, complicated by an attack of pneumonia; and from that time his decline made slow but steady progress—more visible to friends than to himself.

One of the last literary labors which he performed was the preparation, for the National Academy of Sciences, of a memoir of his old friend and colleague at Louisville, Dr. J. Lawrence Smith; and during the last few weeks of his life, when his strength was already largely gone he gave directions, with a touching degree of affection and interest, for the completion of the medal which was to commemorate the labors of his Academic associate. The generous, whole-souled affection for his friends, which characterized his entire life, was never more strongly manifested than during his last days.

The funeral services took place at the College Chapel on the seventeenth of January.

Professor Silliman was married in May, 1840, to Miss Susan H. Forbes of New Haven, eldest child of William J. and Charlotte Root Forbes. Mrs. Silliman died in March, 1878. Four daughters and an only son survive them.

ART. XVI.—*The Organization and Plan of the United States Geological Survey;* by J. W. POWELL. With a map (Plate 1). (Communicated to the National Academy of Sciences at the October meeting in 1884.)

A SCIENTIFIC institution or bureau operating under government authority can be controlled by statute and by superior administrative authority but to a limited extent. These operations are practically carried on by specialists, and they can be controlled only in their financial operations and in the general purposes for which investigations are made. Their methods of investigation are their own,—originate with themselves, and are carried out by themselves. But in relation to the scientific operations of such a government institution, there is an unofficial authority which, though not immediately felt, ultimately steps in to approve or condemn, viz: the body of scientific men of the country; and though their authority is not exercised antecedently and at every stage of the work, yet it is so potent that no national scientific institution can grow and prosper without their approval, but must sooner or later fall and perish unless sustained by their strong influence.

As director of the Geological Survey, I deeply realize that I owe allegiance to the scientific men of the country, and for this reason I desire to present to the National Academy of Sciences the organization and plan of operations of the Survey.

A TOPOGRAPHIC MAP OF THE UNITED STATES.

Sound geologic research is based on geography. Without a good topographic map geology cannot even be thoroughly studied, and the publication of the results of geologic investigation is very imperfect without a good map; but with a good map thorough investigation and simple, intelligible publication become possible. Impelled by these considerations the Survey is making a topographic map of the United States. The geographic basis of this map is a trigonometric survey by which datum points are established throughout the country; that is, base-lines are measured and a triangulation extended therefrom. This trigonometric work is executed on a scale only sufficiently refined for map-making purposes, and will not be directly useful for geodetic purposes in determining the figure of the earth. The hypsometric work is based upon the railroad levels of the country. Throughout the greater part of the country, there is a system of railroad lines, constituting a net-work. The levels or profiles of these roads have been established with reasonable accuracy, and as they cross each other at a multipli-

city of points, a system of checks is afforded, so that the railroad surface of the country can be determined therefrom with all the accuracy necessary for the most refined and elaborate topographic maps. From such a hypsometric basis the reliefs for the whole country are determined, by running lines of levels, by trigonometric construction, and in mountainous regions by barometric observation.

The primary triangulation having been made, the topography is executed by a variety of methods, adapted to the peculiar conditions found in various portions of the country. To a large extent the plane-table is used. In the hands of the topographers of the Geological Survey the plane-table is not simply a portable drafting table for the field; it is practically an instrument of triangulation, and all minor positions of the details of topography are determined through its use by trigonometric construction.

The scale on which the map is made is variable. In some portions of the prairie region, and in the region of the great plains, the topography and the geology alike are simple, and maps on a comparatively small scale are sufficient for practical purposes. For these districts it is proposed to construct the sheets of the map on a scale of 1-250000, or about four miles to the inch. In the mountain regions of the West the geology is more complex, and the topography more intricate; but to a large extent these regions are uninhabited, and to a more limited extent uninhabitable. It would therefore not be wise to make a topographic or geologic survey of the country on an excessively elaborate plan. Over much of this area the sheets of the map will also be constructed on a scale of 1-250000, but in special districts that scale will be increased to 1-125000, and in the case of important mining districts charts will be constructed on a much larger scale. In the eastern portion of the United States two scales are adopted. In the less densely populated country a scale of 1-125000 is used; in the more densely populated regions a scale of 1-62500 is adopted, or about one mile to the inch. But throughout the country a few special districts of great importance, because of complex geologic structure, dense population, or other condition, will require charts on still larger scales. The area of the United States, exclusive of Alaska, is about three million square miles, and a map of the United States, constructed on the plan set fourth above, will require not less than 2600 sheets. It may ultimately prove to require more than that, from the fact that the areas to be surveyed on the larger scale have not been fully determined. Besides the number of sheets in the general map of the United States, there will be several hundred special maps on large scales, as above described.

Such is a brief outline of the plan so far as it has been developed at the present time. In this connection it should be stated that the map of the United States can be completed, with the present organization of the Geological Survey, in about 24 years; but it is greatly to be desired that the time for its completion may be materially diminished by increasing the topographic force of the Geological Survey. We ought to have a good topographic map of the United States by the year 1900. About one-fifth of the whole area of the United States, exclusive of Alaska, has been completed on the above plan. This includes all geographic work done in the United States under the auspices of the General Government and under the auspices of State governments. The map herewith shows those areas that have been surveyed by various organizations on such a scale and in such a manner that the work has been accepted as sufficient for the purposes of the Survey.

Much other work has been done, but not with sufficient refinement and accuracy to be of present value, though such work subserved its purpose in its time. An examination of the map will show that the triangulation of the various organizations is already largely in advance of the topography. The map of the United States will be a great atlas divided into sheets as above indicated. In all of those areas where the survey is on a scale of 1-250000, a page of the atlas will present an area of one degree in longitude and one degree in latitude. Where the scale is 1-125000, a page of the atlas-sheet will represent one-fourth of a degree. Where the scale is 1-62500, the atlas-sheet will represent one-sixteenth of a degree. The degree sheet will be designated by two numbers—one representing latitude, the other longitude. Where the sheets represent fractional degrees, they will be labeled with the same numbers, with the addition of the description of the proper fractional part.

The organization, as at present established, executing this work, is as follows: First, An astronomic and computing division, the officers of which are engaged in determining the geographic coördinates of certain primary points. Second, A triangulation corps engaged in extending a system of triangulation over various portions of the country from measured base-lines. Third, A topographic corps, organized into twenty-seven parties, scattered over various portions of the United States. Such, in brief outline, is the plan for the map of the United States, and the organization by which it is to be made. Mr. Henry Gannett is the Chief Geographer.

Paleontology.

Before giving the outline of the plan for the general geologic survey, it will be better to explain the accessory plans and organizations. There are in the Survey, as at present organized, the following paleontologic laboratories:

1. A laboratory of vertebrate paleontology for formations other than the Quaternary. In connection with this laboratory there is a corps of paleontologists. Professor O. C. Marsh is in charge.

2. There is a laboratory of invertebrate paleontology of Quaternary age, with a corps of paleontologists, Mr. Wm. H. Dall, being in charge.

3. There is a laboratory of invertebrate paleontology of Cenozoic and Mesozoic age, with a corps of paleontologists. Dr. C. A. White is in charge.

4. There is a laboratory of invertebrate paleontology of Paleozoic age, with a corps of paleontologists. Mr. C. D. Walcott is in charge.

5. There is a laboratory of fossil botany, with a corps of paleobotanists, Mr. Lester F. Ward being in charge.

The paleontologists and paleobotanists connected with the laboratories above described, study and discuss in reports the fossils collected by the general geologists in the field. They also supplement the work of the field geologists by making special collections in important districts and at critical horizons; but the paleontologists are not held responsible for areal and structural geology on the one hand, and the geologists are not held responsible for paleontology on the other hand. In addition to the large number of paleontologists on the regular work of the Geological Survey, as above described, several paleontologists are engaged from time to time to make special studies.

Chemistry.

There is a chemic laboratory attached to the Survey, with a large corps of chemists engaged in a great variety of researches relating to the constitution of waters, minerals, ores and rocks. A part of the work of this corps is to study the methods of metamorphism and the paragenesis of minerals, and in this connection the chemists do work in the field; but to a large extent they are occupied with the study of the materials collected by the field geologists. Professor F. W. Clarke is in charge of this department.

Physical Researches.

There is a physical laboratory in the Survey, with a small corps of men engaged in certain physical researches of prime importance to geologic philosophy. These researches are experimental, and relate to the effect of temperatures, pressures, etc., on rocks. This laboratory is under the charge of the Chief Chemist.

Lithology.

There is a lithologic laboratory in the Survey, with a large corps of lithologists engaged in the microscopic study of rocks. These lithologists are field geologists, who examine the collections made by themselves.

Statistics.

There is in the Survey a division of mining statistics, with a large corps of men engaged in statistic work, the results of which are published in an annual report entitled "Mineral Resources." Mr. Albert Williams, Jr., is the Chief Statistician of the Survey.

Illustrations.

There is in the Survey a division organized for the purpose of preparing illustrations for paleontologic and geologic reports. Mr. W. H. Holmes is in charge of this division. Illustrations will not hereafter be used for embellishment, but will be strictly confined to the illustration of the text and the presentation of such facts as can be best exhibited by figures and diagrams. All illustrations will, as far as possible, be produced by relief methods, such as wood-engraving, photo-engraving, etc. As large numbers of the reports of the Survey are published, this plan is demanded for economic reasons; but there is another consideration believed to be of still greater importance: illustrations made on stone cannot be used after the first edition, as they deteriorate somewhat by time, and it is customary to use the same lithographic stone for various purposes from time to time. The illustrations made for the reports of the Survey, if on relief-plates that can be cheaply electrotyped, can be used again when needed. This is especially desirable in paleontology, where previously published figures can be introduced for comparative purposes. There are two methods of studying the extinct life of the globe. Fossils are indices of geological formations, and must be grouped by formations to subserve the purpose of geologists. Fossils also have their biologic relations, and should be studied and arranged in biologic groups. Under the plan adopted by the Survey, the illustra-

tions can be used over and over again for such purposes when needed, as reproduction can be made at the small cost of electrotyping. These same illustrations can be used by the public at large in scientific periodicals, text-books, etc. All the illustrations made by the Geological Survey are held for the public to be used in this manner.

Library.

The library of the Survey now contains more than 25,000 volumes, and is rapidly growing by means of exchanges. It is found necessary to purchase but few books. The librarian, Mr. C. C. Darwin, has a corps of assistants engaged in bibliographic work. It is proposed to prepare a catalogue of American and foreign publications upon American geology, which is to be a general authors' catalogue. In addition to this, it is proposed to publish bibliographies proper of special subjects constituting integral parts of the science of geology.

Publications.

The publications of the Survey are in three series: Annual Reports, Bulletins and Monographs. The Annual Report constitutes a part of the Report of the Secretary of the Interior for each year, but is a distinct volume. This contains a brief summary of the purposes, plans and operations of the Survey, prepared by the Director, and short administrative reports from the chiefs of divisions, the whole followed by scientific papers. These papers are selected as being those of most general interest, the object being to make the Annual Report a somewhat popular account of the doings of the Survey, that it may be widely read by the intelligent people of the country. Of this 5650 copies are published as a part of the Secretary's report, and are distributed by the Secretary of the Interior, Senators and Members of the House of Representatives; and an extra edition is annually ordered of 15,000 copies, distributed by the Survey and members of the Senate and House of Representatives. Four Annual Reports have been published; the Fifth is now in the hands of the printer.

The Bulletins of the Survey are short papers; and through them somewhat speedy publication is attained. Each Bulletin is devoted to some specific topic, in order that the material ultimately published in the Bulletins can be classified in any manner desired by scientific men. Nine Bulletins have been published, and seven are in press. The Bulletins already published vary in size from 5 to 325 pages each; they are sold at the cost of press-work and paper, and vary in price from five to twenty cents each. 4900 copies of each Bulletin are pub-

lished; 1900 are distributed by Congress, 3000 are held for sale and exchange by the Geological Survey.

The Monographs of the Survey are quarto volumes. By this method of publication the more important and elaborate papers are given to the public. Six Monographs, with two atlases, have been issued; five Monographs, with two atlases, are in press. 1900 copies of each Monograph are distributed by Congress; 3000 are held for sale and exchange by the Survey at the cost of press-work, paper and binding. They vary in price from $1.05 to $11.

The chiefs of divisions supervise the publications that originate in their several corps. The general editorial supervision is exercised by the Chief Clerk of the Survey, Mr. James C. Pilling.

General Geology.

In organizing the general geologic work, it became necessary, first, to consider what had already been done in various portions of the United States; and for this purpose the compilation of a general geologic map of the United States was begun, together with a Thesaurus of American formations. In addition to this the bibliographic work previously described was initiated, so that the literature relating to American geology should be readily accessible to the workers in the Survey. At this point it became necessary to consider the best methods of apportioning the work; that is, the best methods of dividing the geologic work into parts to be assigned to the different corps of observers. A strictly geographic apportionment was not deemed wise, from the fact that an unscientific division of labor would result, and the same classes of problems would to a large extent be relegated to the several corps operating in field and in the laboratory. It was thought best to divide the work, as far as possible, by subject-matter rather than by territorial areas; yet to some extent the two methods of division will coincide. There are in the survey at present:

First, a division of glacial geology, and Prof. T. C. Chamberlin, formerly State Geologist of Wisconsin, is at its head, with a strong corps of assistants. There is an important field for which definite provision has not yet been made, namely, the study of the loess that constitutes the bluff formations of the Mississippi River and its tributaries. But as this loess proves to be intimately associated with the glacial formations of the same region, it is probable that it will eventually be relegated to the glacial division. Perhaps the division may eventually grow to such an extent that its field of operations will include the whole Quaternary geology.

Second, a division of volcanic geology is organized and Capt. Clarence E. Dutton, of the Ordnance Corps of the Army, is placed in charge, also with a strong corps of assistants.

Third and fourth, two divisions have been organized to prosecute work on the Archæan rocks, embracing within their field not only all rocks of Archæan age, but all metamorphic crystalline schists, of whatever age they may be found. The first division has for its chief, Prof. Raphael Pumpelly, assisted by a corps of geologists, and the field of his work is the crystalline schists of the Appalachian region, or eastern portion of the United States, extending from northern New England to Georgia. He will also include in his studies certain Paleozoic formations which are immediately connected with the crystalline schists and involved in their orographic structure.

The second division for the study of this class of rocks is in charge of Prof. Roland D. Irving, with a corps of geologists, and his field of operation is in the Lake Superior region. It is not proposed at present to undertake the study of the crystalline schists of the Rocky Mountain region.

Fifth, another division has been organized for the study of the areal, structural, and historical geology of the Appalachian region, extending from the Atlantic, westward, to the zone which separates the mountain region from the great valley of the Mississippi. Mr. G. K. Gilbert has charge of this work, and has a large corps of assistants.

Sixth, it seemed desirable, partly for scientific reasons and partly for administrative reasons, that a thorough topographic and geologic survey should be made of the Yellowstone Park, and Mr. Arnold Hague is in charge of the work, with a corps of assistants. When it is completed, his field will be expanded so as to include a large part of the Rocky Mountain region, but the extent of the field is not yet determined.

It will thus be seen that the general geologic work relating to those areas where the terranes are composed of fossiliferous formations is very imperfectly and incompletely organized. The reason for this is two fold: first, the work cannot be performed very successfully until the maps are made; second, the Geological Survey is necessarily diverting much of its force to the construction of maps, and cannot with present appropriations expand the geologic corps so as to extend systematic work in the field over the entire country.

Economic Geology.

Under the organic law of the Geological Survey, investigations in economic geology are restricted to those States and Territories in which there are public lands; the extension of

the work into the eastern portion of the United States included only that part relating to general geology. Two mining divisions are organized. One, in charge of Mr. George F. Becker, with headquarters at San Francisco, California, is at the present time engaged in the study of the quicksilver districts of California. The other, under charge of Mr. S. F. Emmons, with headquarters at Denver, Colorado, is engaged in studying various mining districts in that State, including silver, gold, iron and coal areas. Each division has a corps of assistants. The lignite coals of the upper Missouri, also, are under investigation by Mr. Bailey Willis, with a corps of assistants.

Employés.

The employés on the Geological Survey at the close of September, 1884, were as follows:

Appointed by the President, by and with the advice and consent of the Senate (Director), 1.

Appointed by the Secretary of the Interior, on the recommendation of the Director of the Survey, 134.

Employed by the chiefs of parties in the field, 148.

Appointments.

Three classes of appointments are made on the Survey. The statute provides that "the scientific employés of the Geological Survey shall be selected by the Director, subject to the approval of the Secretary of the Interior, exclusively for their qualifications as professional experts." The provisions of this statute apply to all those cases where scientific men are employed who have established a reputation, and in asking for their appointment the Director specifically states his reasons, setting forth the work in which the person is to be employed, together with his qualifications, especially enumerating and characterizing his published works. On such recommendations appointments are invariably made. Young men who have not established a reputation in scientific research, are selected through the agency of the Civil Service Commission on special examination, the papers for which are prepared in the Geological Survey. About one-half of the employés, however, are temporary, being engaged for services lasting for a few days or a few months only, largely in the field, and coming under two classes: skilled laborers and common laborers. Such persons are employed by the Director or by the heads of divisions, and are discharged from the service when no longer needed. It will be seen that the Director is responsible for the selection of the employés, directly for those whom he recommends for appointment, and indirectly for those selected by the

Civil Service Commission, as he permanently retains in the work. If, then, improper persons are employed, it is wholly the Director's fault.

The appropriations made for the Geological Survey for the fiscal year ending June 30, 1885, aggregate the sum of $504,040. This sum does not include the amount appropriated for ethnologic researches, $40,000. Nor are the expenses for engraving and printing paid for from the above appropriations, but from appropriations made for the work under the direction of the Public Printer. It is estimated that the amount needed for engraving and printing for the same fiscal year will exceed $200,000.

The Relation of the Government Survey to State Surveys.

The United States Geological Survey is on friendly relations with the various State Surveys. Between the Government Survey and the State Survey of New York, there is direct coöperation. The State Survey of Pennsylvania has rendered valuable assistance to the Government Survey, and negotiations have been entered into for closer relations and more thorough coöperation. The State Surveys of North Carolina, Kentucky and Alabama, are also coöperating with the Government Survey, and the Director of the Government Survey is doing all within his power to revive State Surveys. The field for geologic research in the United States is of great magnitude, and the best results can be accomplished only by the labors of many scientific men engaged for a long term of years. For this reason it is believed that surveys should be established in all of the States and Territories. There is work enough for all, and the establishment of local surveys would greatly assist the general work prosecuted under the auspices of the Government, and prevent it from falling into perfunctory channels. Its vigor and health will doubtless be promoted by all thorough local research.

It may be of interest to scientific men to know that the Director finds that in presenting the general results, interests, and needs of the Survey to Congress, and to Committees of Congress, a thorough appreciation of the value of scientific research is shown by the statesmen of the country. Questions relating to immediately economic values are asked, as they should be; but questions relating to sound administration, wise methods of investigation, and important scientific results are vigorously urged, and the principle is recognized that all sound scientific research conduces to the welfare of the people, not only by increasing knowledge, but ultimately by affecting all the industries of the people.

Art. XVII.—*Memorial of George Bentham;* by Asa Gray.

[From the Report of the Council of the American Academy of Arts and Sciences, for the year 1884–5.)

George Bentham, one of the most distinguished botanists of the present century, and at the time of his death one of the oldest, was born at Stoke, a suburb of Portsmouth, September 22, 1800. He died at his house, No. 25 Wilton Place, London, on the 10th of September, 1884, a few days short of 84 years old. His paternal grandfather, Jeremiah Bentham, a London attorney or solicitor, had two sons, who both became men of mark, Jeremy and Samuel. The latter and younger had two sons, only one of whom, the subject of this memoir, lived to manhood. George Bentham's mother was a daughter of Dr. George Fordyce, a Scottish physician who settled in London, was a Fellow of the Royal Society, a lecturer on chemistry, and the author of some able medical works, also of a treatise upon Agriculture and Vegetation. It was from his mother that George Bentham early imbibed a fondness for botany.

The early part of his life and education was somewhat eventful and peculiar, and in strong contrast with the later. His father, General, subsequently Sir Samuel Bentham, was an adept in naval architecture. At the age of twenty-two he visited the arsenals of the Baltic for the improvement of his knowledge; thence he traveled far into Siberia. He became intimate with Prince Potemkin, by whom he was induced to enter the civil and afterwards the military service of the Empress Catharine. He took part in a naval action against the Turks on the Black Sea, and was rewarded with the command of a regiment stationed in Siberia, with which he traversed the country even to the frontiers of China. After ten years he returned to England, where his inventive skill and experience found a fitting field in the service of the Admiralty, in which he attained the post of Inspector-General of Naval Works. Among the services he rendered was that of bringing to England the distinguished engineer, Isambard Mark Brunel. In the year 1805, Gen. Bentham was sent by the Admiralty to St. Petersburg to superintend the building in Russia of vessels for the British Navy. He took his family with him; and there began the education of George Bentham, in the fifth year of his age, under the charge of a Russian lady who could speak no English, where he learned to converse fluently in Russian, French, and German, besides acquiring the rudiments of Latin as taught by a Russian priest. On the way back to England two or three years later, the detention of a month or

two in Sweden gave opportunity for learning enough of Swedish to converse in that language and to read it with tolerable ease in after life. Returning to England the family settled at Hampstead, and the children pursued their studies under private tutors. In the years 1812–13, during the excitement produced by the French invasion of Russia and the burning of Moscow, our young polyglot "budded into an author, by translating (along with his brother and sister) and contributing to a London magazine a series of articles from the Russian newspapers, detailing the operations of the armies." In 1814, upon the downfall of Napoleon, the Bentham family crossed over to France, prepared for a long stay, remained in the country (at Tours, Saumur, and Paris) during the hundred days preceding Napoleon's final overthrow; and in 1816 Sir Samuel Bentham set out upon a prolonged and singular family tour, *en caravane*, through the western and southern departments of France. To quote from the published account from which most of these biographical details are drawn, and which were taken from Mr. Bentham's own memoranda:*

"The *cortége* consisted of a two-horse coach fitted up as a sleeping apartment; a long, low, two-wheeled, one-horse spring van for Gen. and Mrs. Bentham, furnished with a library and piano; and another, also furnished, for his daughters and their governess. The plan followed was to travel by day from one place of interest to another, bivouacking at night by the road, or in the garden of a friend, or in the precincts of the prefectures, to which latter he had credentials from the authorities in the capital. In this way he visited Orleans, Tours, Angoulême, Bordeaux, Toulouse, Montpellier, and finally Montauban, where a lengthened stay was made in a country house hired for the purpose. From Montauban (the *cortége* having broken down in some way) they proceeded still by private conveyances to Carcassone, Narbonnes, Nîmes, Tarascon, Marseilles, Toulon, Hyères."

It was in the early part of this tour that young Bentham's attention was first turned to botany. Happening to take up DeCandolle's edition of Lamarck's *Flore Française*, which his mother, who was fond of the subject, had just purchased, he was struck with the methodical analytical tables, and he proceeded immediately to apply them to the first plant he could lay hold of. "His success led him to pursue the diversion of naming every plant he met with." During his long stay at Montauban he entered as a student in the Protestant theological school of that town, pursuing, "with ardor the courses of mathematics, Hebrew, and comparative philology, the latter a favorite study in after life," and at home giving himself to

* An article in Nature, October 2, 1884, by Sir Joseph Dawson Hooker.

music, in which he was remarkably gifted, to Spanish, to botany, and, with great relish, to society. Soon after, the family was established upon a property of 2,000 acres, purchased by his father in the vicinity of Montpellier. Here he resumed the intimacy of his boyhood with John Stuart Mill, who was five years his junior, and whose life-long taste for botany was probably fixed during this residence of seven or eight months in the Bentham family in the year 1820. About this time Bentham occupied himself with ornithology and then with entomology, finding time, however, for another line of study; for at the age of twenty he had begun a translation into French of his uncle Jeremy's Chrestomathia, which was published in Paris some years afterwards, and he soon after translated also the essay on Nomenclature and Classification. This was followed by his own *Essai sur la Nomenclature et Classification*, published in Paris. This, his original scientific production, was one of some mark, for it is praised by Stanley-Jevons in his recent History of the Sciences.

On attaining his majority, his elder and only brother having died, he was placed in management of his father's Provençal estate, an employment which he took up with alacrity and prosecuted with success, turning to practical account his methodical habits, his indomitable industry, and his familiarity with Provençal country life and language. The latter he spoke like a native. A language always seemed to come to him without effort. Meanwhile his leisure hours were given to philosophical studies, his holidays to botanical excursions into the Cevennes and the Pyrenees. In the year 1823, a visit to England upon business relating to his father's French estate, where it seemed probable that he was to spend his life, was followed by circumstances which gave him back to his native country. He brought to his uncle Jeremy a French translation of the latter's Chrestomathia; he made the acquaintance of Sir James Edward Smith, Robert Brown, Lambert, Don, and the other English botanists of the day; visited Sir William, then Professor Hooker, at Glasgow, and Walker Arnott in Edinburgh; took the latter with him the next summer to France, where the two botanists herborized together in Languedoc and the Pyrenees; and, returning to London, he accepted his uncle's pressing invitation to remain and devote a portion of his time to the preparation of the latter's manuscripts for the press, at the same time pursuing legal studies at Lincoln's Inn. He was in due time called to the bar, and in 1832 he held his first and last brief. In that year Jeremy Bentham died, bequeathing most of his property to his nephew. This was much less than was expected, owing to bad management on his uncle's part and to the extravagant sums spent by his

executors in the publication of the philosopher's posthumous works. But it sufficed, in connection with the paternal inheritance, which fell to him the year previous, for the modest independence which allowed of undistracted devotion to his favorite studies. These were for a time divided between botany, jurisprudence, and logic, not to speak of editorial work upon his father's papers relating to the management of the navy and the administration of the national dock yards.

The first publication was botanical, and was published in Paris, in the year 1826, his *Catalogue des Plantes Indigènes des Pyrénées et du Bas Languedoc.* To this is prefixed an interesting narrative of a botanical tour in the Pyrenees, and some remarks upon the mode of preparing such catalogues in order to their greatest utility,—remarks which already evince the wisdom for which he was distinguished in after years. He also reformed and re-elaborated four difficult genera of the district, Cerastium, Orobanche, Helianthemum, and Medicago. The next, perhaps, was an article upon codification—wholly disagreeing with his uncle—which attracted the attention of Brougham, Hume and O'Connell; also one upon the laws affecting larceny, which Sir Robert Peel complimented and made use of, and another on the law of real property.

But his most considerable work of the period received scant attention at the time from those most interested in the subject, and passed from its birth into oblivion, from which only in these later years has it been rescued, yet without word or sign from its author. This work (of 287 octavo pages) was published in London in 1827, under the title of "*Outline of a New System of Logic, with a critical examination of Dr. Whately's Elements of Logic.*" It was in this book that the quantification of the predicate was first systematically applied, in such wise that Stanley-Jevons* declares it to be "undoubtedly the most fruitful discovery made in abstract logical science since the time of Aristotle." Before sixty copies of the book had been sold, the publisher became bankrupt, and the whole impression of this work of a young and unknown author was sold for waste paper. One of the extant copies, however, came into the hands of the distinguished philosopher, Sir William Hamilton, to whom the discovery of the quantification of the predicate was credited, and who, in claiming it, brought "an acrimonious charge of plagiarism" against Professor De Morgan upon this very subject. Yet this very book of Mr. Bentham is one of the ten placed by title at the head of Sir Wm. Hamilton's article on logic in the Edinburgh Review for April, 1833, is once or twice referred to in the article, and, a dozen years later, in the course of the controversy with De Morgan, Sir William

* In Contemporary Review, xxi, 1873, p. 823.

alluded to this article as containing the germs of his discovery. We may imagine the avidity with which De Morgan, injuriously attacked, would have seized upon Mr. Bentham's book if he had known of it. It is not so easy to understand how Mr. Bentham—although now absorbed in botanical researches—could have overlooked this controversy in the Athenæum, or how, if he knew of it, he could have kept silence. It was only at the close of the year 1850, that Mr. Warlow sent from the coast of Wales a letter to the Athenæum, in which he refers to Bentham's book as one which had long before anticipated this interesting discovery. Although Hamilton himself never offered explanation of his now unpleasant position (for the note obliquely referring to the matter in the second edition of his Discussions is not an explanation), Mr. Baine did (in the Athenæum for Feb. 1, 1851) immediately endeavor to discredit the importance of Bentham's work, and again in 1873 (Contemporary Review, xxi), in reply to Herbert Spencer's reclamation of Bentham's discovery. To this Stanley-Jevons made reply in the same volume (pp. 821–824); and later, in his Principles of Science (ii. 387), this competent and impartial judge, in speaking of the connection of Bentham's work "with the great discovery of the quantification of the predicate," adds:

"I must continue to hold that the principle of quantification is explicitly stated by Mr. Bentham; and it must be regarded as a remarkable fact in the history of logic, that Hamilton, while vindicating in 1847, his own claims to originality and priority as against the scheme of De Morgan, should have overlooked the much earlier and more closely related discoveries of Bentham."

It must be that Hamilton reviewed Bentham's book without reading it through, or that its ideas did not at the time leave any conscious impression upon the reviewer's mind, yet may have fructified afterwards.

After his uncle's death in 1822, Mr. Bentham gave his undivided attention to Botany. He became a Fellow of the Linnean society in 1828. Robert Brown soon after presented his name to the Royal Society, but withdrew it before the election, to mark the dissatisfaction on the part of scientific men with the management of the society when a Royal Duke was made president. Consequently he did not become F. R. S. until 1862. In 1829, when the Royal Horticultural Society was much embarrassed, he accepted the position of Honorary Secretary, with his friend Lindley as associate. Under their management it was soon extricated from its perilous condition, attained its highest prosperity and renown, and did its best work for horticulture and botany. In 1833 he married the daughter of Sir Harford Brydges, for many years British

Ambassador in Persia, and the next year he took up his residence in the house in Queen Square Place, Westminster, inherited from his uncle, in which Jeremy Bentham and his own paternal grandfather had dwelt for almost a century. The house no longer exists, but upon its site stands the western wing of the "Queen Anne Mansions." The summer of 1836 was passed in Germany, at points of botanical interest and wherever the principal herbaria are preserved, the whole winter in Vienna. Some account of this tour and interesting memoranda of the botanists, gardens, and herbaria visited, communicated in familiar letters to Sir William Hooker, were printed at the time (without the author's name) in the second volume of the Companion to the Botanical Magazine. Similar visits for botanical investigation, mingled with recreation, were made almost every summer to various parts of the continent; in one of them he revisited the scenes of his early boyhood in Russia, traveled with Mrs. Bentham to the fair at Nischnii-Novgorod, and thence to Odessa, by the rude litter-like conveyances of the country.

In 1842 he removed with his herbarium to Pontrilas House in Herefordshire, an Elizabethan mansion belonging to his brother-in-law, and combined there the life of a country squire with that of a diligent student, until 1854, when, returning to London, he presented his herbarium and botanical library to the Royal Gardens at Kew, where they were added to the still larger collections of Sir William Hooker. After a short interval Mr. Bentham took up his residence at No. 25 Wilton Place, between Belgrave Square and Hyde Park, which was his home for the rest of his life. Thence, autumn holidays excepted, with perfect regularity for five days in the week he resorted to Kew, pursued his botanical investigations from ten to four o'clock, then, returning, he wrote out the notes of his day's work before dinner, hardly ever breaking his fast in the long interval. With such methodical habits, with freedom from professional or administrative functions which consume the precious time of most botanists, with steady devotion to his chosen work, and with nearly all authentic materials and needful appliances at hand or within reach, it is not surprising that he should have undertaken and have so well accomplished such a vast amount of work: and he has the crowning merit and happy fortune of having completed all that he undertook.

Nor did he decline duties of administration and counsel which could rightly be asked of him. The Presidency of the Linnean Society, which he accepted and held for eleven years (1863 to 1874), was no sinecure to him; for he is said to have taken on no small part of the work of Secretary, Treasurer, and Botanical Editor. Somewhat to the surprise of his younger

associates, who knew him only as the recluse student, he made proof in age of the fine talent for business and the conduct of affairs which had distinguished his prime in the management of the Horticultural Society; and in his annual presidential addresses, which form a volume of permanent value, his discussions of general as well as of particular scientific questions and interests bring out prominently the breadth and fulness of his knowledge and the soundness of his judgment.

The years which followed his retirement from the chair of the Linnean Society, at the age of seventy-three, were no less laborious or less productive than those preceding; at the age of eighty (as the writer can testify) the diminution of bodily strength had wrought no obvious abatement of mental power and not much of facility; and he was able to finish in the spring of 1883 the great work upon which he was engaged. As was natural his corporeal strength gave way when his work was done. After a year and a half of increasing debility he died simply of old age—the survivor of his wife for three or four years, the last of the Benthams, for he had no children, nor any collateral descendants of the name.

A large part of his modest fortune was bequeathed to the Linnean Society, to the Royal Society, for its scientific relief fund, and in other trusts for the promotion of the science to which his long life was so perseveringly devoted.

The record of no small and no unimportant part of a naturalist's work is to be found in scattered papers, and those of George Bentham are quite too numerous for individual mention. The series begins with an article upon *Labiatæ*, published in the Linnæa in 1831; it closes with one in the Journal of the Linnean Society, read April 19, 1883, indicating the parts taken by the two authors in the elaboration of the Genera Plantarum, then completed. Counting from the date of the Catalogue of Pyrenean plants, 1826, there are fifty-seven years of authorship. His first substantial volume in botany was the *Labiatarum Genera et Species*, or a description of the genera and species of plants of the order *Labiatæ* with their general history, characters, affinities, and geographical distribution, an octavo of almost 800 pages, of which the first part was published in 1832, the last in 1836. He found even the European part of this large order in much confusion; his monograph left its seventeen hundred and more of species so well arranged (under 107 genera and in tribes of his own creation), that there was little to alter, except as to the rank of certain groups, when he revised them for the Prodromus in 1848, and finally revised the genera (now increased to 136, and with estimated species almost doubled) for the Genera Plantarum in 1876. Although the work of a beginner, it took rank as the best extant monograph of its kind,

viz: one of a large natural order, without plates. In it Mr. Bentham first set the example, in any large way, of consulting all the available herbaria for the inspection and determination of type-specimens. To this end he made journeys to the continent every year from 1830 to 1834, visiting nearly all the public and larger private herbaria.

In the years during which the monograph of *Labiatæ* was in progress, Mr. Bentham elaborated and published the earlier of the papers which have particularly connected his name with North American Botany. These are, first, the reports on some of the new ornamental plants raised in the Horticultural Society's Garden from seeds collected in Western North America by Douglas, under the auspices of that society, by which were first made known to botanists and florists so many of the characteristic genera and species of Oregon and California, now familiar in gardens, Gilias and Nemophilas, Limnanthes, Phacelias, Brodiæas, Calochorti, Eschscholtzias, Collinsias, and the like; then the monograph of *Hydrophylleæ* (1834), followed the next year by that on *Hosackia*, and that on the *Eriogoneæ*,—all American and chiefly North American plants,—the first fruits of a great harvest which even now has not wholly been gathered in, the field is so vast, though the laborers have not been few. Later the *Plantæ Hartwegianæ*, an octavo volume begun in 1839, but finished in 1857 with the Californian collections; and in 1844, the *Botany of the Voyage of the Sulphur*, in quarto, the first part of which relates to Californian botany. The various papers upon South American Botany are even more numerous; one of them being that in which Heliamphora, of British Guiana, a new genus of Pitcher Plants, of the Sarracenia family, was established.

Bentham's labors upon the great order *Leguminosæ* began early, with his *Commentationes de Leguminosarum Generibus*, published in the Annals of the Vienna Museum, being the work of a winter's holiday (1836–7) passed in that capital, in the herbarium then directed by Endlicher. This was followed by a series of papers, mostly monographs of genera, in Hooker's Journal of Botany, in the Journal of the Linnean Society, and elsewhere, by the elaboration of the order for the imperial Flora Brasiliensis, and later, by the *Revision of the Genus Cassia* and that of the *Sub-order Mimoseæ*, in the Transactions of the Linnean Society, the latter (a quarto volume in size) published as late as the year 1875. Both are perfect models of monographical work.

An important series of monographs in another and more condensed form was contributed to DeCandolle's Prodromus, namely, the Tribe *Ericeæ* in the seventh volume, the *Polemoniaceæ* in the ninth, the *Scrophulariaceæ* in the tenth, the *Labiatæ*

forming the greater part of the twelfth, and the *Eriogoneæ* in the fourteenth; these together filling 1133 pages according to the surviving editor. If not quite the largest collaborator of the DeCandolles, as counted in pages, he was so in the number of plants described, and his work was of the best. It was also ready in time, which is more than can be said of the collaborators in general.

There are few parts of the world upon the botany of which Mr. Bentham has not touched—Tropical America, in the ample collections of Mr. Spruce, and those of Hartweg, distributed, and the former partly and the latter wholly determined by him, as also Hinds' collections made in the voyage of the Sulphur, besides what has already been adverted to; Polynesia, from Hinds' and Barclay's collections; Western Tropical Africa, in the Niger Flora, most of the *Flora Nigritiana* being from his hand; the *Flora Hongkongensis*, in which he began the series of British Colonial floras, and finally that vast work, the *Flora Australiensis*, in seven volumes, which the author began when he was over sixty years old and finished when he was seventy-seven. Nor did he neglect the cultivation of the narrow and more exhausted field of British Botany. His *Handbook of the British Flora*, for the use of beginners and amateurs, published in 1858, has gone through four large editions. Its special object was to enable a beginner or a mere amateur, with little or no previous scientific knowledge and without assistance, to work out understandingly the characters by which the plants of a limited flora may be distinguished from each other, these being expressed as much as possible in ordinary language, or in such technical terms as could be fully explained in the book itself and easily apprehended by the learner. The immediate and continued popularity of this handy volume, bringing the light of full knowledge and sound method to guide the beginner's way, illustrates the advantage of having elementary works prepared by a master of the subject, whenever the master will take the necessary pains. To the same end, the author prepared for this volume an excellent and terse introduction to structural and descriptive botany, which has been prefixed to all the Colonial Floras. In the first edition to this British Flora it was attempted to use or to give English names to the genera and species throughout. This could be done only in such a familiar and well-trodden field as Britain, where almost every plant was familiar; but even here it failed, and in later editions the popular names were relegated to a subordinate position.

It has been stated that Mr Bentham was over sixty years old when he undertook the *Flora Australiensis*, and he was seventy-seven when he brought this vast work to completion,

assisted only in notes and preliminary studies by Baron von Mueller of Melbourne. About the same time he courageously undertook the still greater task of a new *Genera Plantarum*, to be worked out, not, like that of Endlicher, mainly by the compilation of published characters into a common formula, but by an actual examination of the extant materials, primarily those of the Kew herbaria,– this work, however, in conjunction with his intimate associate, Sir Joseph Hooker. This work is the only "joint production" in which Mr. Bentham ever engaged. The relations and position of the two authors made the association every way satisfactory, and the magnitude of the task made it necessary. The training and the experience of the two associates were very different and in some ways complemental, one having the greatest herbarium knowledge of any living botanist, the other, the widest and keenest observer of vegetable life under "whatever climes the sun's bright circle warms," as well as of Antarctic regions which it warms very little. It would be expected, on the principle "juniores ad labores," that the laboring oar would be taken by the younger of the pair. It was long and severe work for both; but the veteran was happily quite free from, and his companion heavily weighted by, onerous official duties and cares; and so it came to pass that about two-thirds of the orders and genera were elaborated by Mr. Bentham. In April, 1883, the completion of the work (i. e. of the genera of Phænogamous plants, to which it was limited) closed this long and exemplary botanical career; and the short account which he gave to the Linnean Society on the nineteenth of that month, specifying the conduct of the work and the part of the respective authors, was his last publication.

In this connexion, mention should also be made of the essays (which he simply calls "Notes") upon some of the more important orders which he investigated for the Genera Plantarum,—the Compositæ, the Campanulaceous and the Oleaceous orders, the Monocotyledoneæ as to classification, the Euphorbiaceæ, the Orchis family, the Cyperaceæ and the Gramineæ. These are not mere abstracts, issued in advance, but critical dissertations, with occasional discussions of some general or particular question of terminology or morphology. When collected they form a stout volume, which, along with the volume made up of his anniversary addresses when president of the Linnean Society, and the paper on the progress and state of systematic botany, read to the British Association for the Advancement of Science in 1874, should be much considered by those who would form a just idea of the largeness of Mr. Bentham's knowledge and the character of his work.

It will have been seen that Mr. Bentham confined himself to the Phænogamia, to morphological, taxonomical and descriptive work, not paying attention to the Cryptogamia below the Ferns, nor to vegetable anatomy, physiology, or palæontology. He was what will now be called a botanist of the old school. Up to middle age and beyond he used rather to regard himself as an amateur, pursuing botany as an intellectual exercise. "There are diversities of gifts;" perhaps no professional naturalist ever made more of his, certainly no one ever labored more diligently, nor indeed more successfully over so wide a field, within these chosen lines. For extent and variety of good work accomplished, for an intuitive sense of method, for lucidity and accuracy, and for insight, George Bentham may fairly be compared with Linnæus, DeCandolle, and Robert Brown.

His long life was a perfect and precious example, much needed in this age, of persevering and thorough devotion to Science while unconstrained as well as untrammeled by professional duty or necessity. For those endowed with leisure, to "live laborious days" in her service, it is not a common achievement.

The tribute which the American Academy of Sciences pays to the memory of a deceased Foreign Honorary Member might here fittingly conclude. But one who knew him long and well may be allowed to add a word upon the personal characteristics of the subject of this memorial; the more so that he is himself greatly indebted for generous help. For, long ago, when in special need of botanical assistance, Mr. Bentham invited him and his companion to his house at Pontrilas, and devoted the greater part of his time for two months to this service. Mr. Bentham's great reserve and dryness in general intercourse and his avoidance of publicity might give the impression of an unsympathetic nature. But he was indeed most amiable, warm-hearted, and even genial, "the kindest of helpmates," the most disinterested of friends.

ART. XVIII.—*Paleontologic Notes;* by CHARLES D. WALCOTT, *of the U. S. Geological Survey.*

IN reviewing the material from the St. John Group of New Brunswick, contained in the Hartt collection at Cornell University, the following species were found:

Eocystites primævus Billings.
Lingula? Dawsoni Matthew.
Acrothele Matthewi Hartt, sp.
Linnarssonia transversa Hartt, sp.
Obolella?, sp. undet.
Orthis Billingsi Hartt.
Orthis, sp. ?.
Stenotheca Acadica Hartt, sp.
Harttia Matthewi Walcott, n. gen., n. sp.
Hyolithes Acadica Hartt.
H. Danianus Matthew, mss.
H. Micmac Matthew, mss.
Agnostus Acadicus Hartt.
Microdiscus Dawsoni Hartt.
M. punctatus Salter?.
Paradoxides lamellatus Hartt.
P. Acadicus Matthew.
P. Etiminicus Matthew.
Conocoryphe Matthewi Hartt.
C. elegans Hartt.
C. (Salteria) Baileyi Hartt.
Ptychoparia Robbi Hartt.
P. Ouangondiana Hartt.
P. Ouangondiana, var. *Aurora* Hartt.
P. quadrata Hartt.
P. Orestes Hartt.
P. Orestes, var. *Thersites* Hartt.
P. tener Hartt.

The *Obolella transversa* of Hartt is clearly allied to *O. sagittalis* Salter, and is not a true Obolella, but represents a genus not yet defined.

Mr. Davidson* called attention to the differences between *O. chromatica*, the type of the genus, and *O. sagittalis*. Later Mr. S. W. Ford† compared the two forms, and suggested that *O. sagittalis* probably represented a new genus. When studying the Obolella-like forms from Nevada, I arrived at the same conclusion (1882),‡ and placed the species in three groups, taking *O. gemma* Bill., *O. (desquamata) = crassa* Hall, as typical of the

* Monogr. Brit. Foss. Brach., p. 338. † This Journal, vol. xxi, p. 133, 1881.
‡ Pal. Eureka District, Mon. viii, U. S. Geol. Survey.

genus Obolella; *O.? polita* Hall, *O. ambigua* Walcott, as representing the second group, and *O. sagittalis* the third. In studying *O. transversa* Hartt, the similarity between it and *O. sagittalis* was noted. For this type the following genus is proposed in honor of the late Dr. G. Linnarsson.

Family OBOLIDÆ.

Linnarssonia, n. gen.

Shell calcareous, transversely or longitudinally ovate, subcircular; convex in the typical species; valves inarticulate. Ventral valve convex with the eccentric apex perforated by a minute foramen; no area; cardinal edge thin. Dorsal valve convex in the species thus far known; without any area.

In the interior of the ventral valve two oval and oblique scars lie each side of the slightly raised rim surrounding the minute foraminal opening and close to the posterior margin; from the foraminal rim a groove extends obliquely forward and outward on each side, so as to enclose a projecting ∧ shaped ridge that is highest at its posterior margin, just in front of the circular foraminal opening.

In the interior of the dorsal valve two large, irregularly circular scars are situated close to the posterior margin and separated by a low, flat ridge that extends forward between the two small divaricator scars. Type, *Obolella transversa* Hartt.

Mr. Davidson did not find that the ventral valve of *Obolella sagittalis* was perforated, but if finely preserved specimens of the exterior of the valve can be obtained, I have little doubt but that the apex will be found to be perforated by a minute foramen.

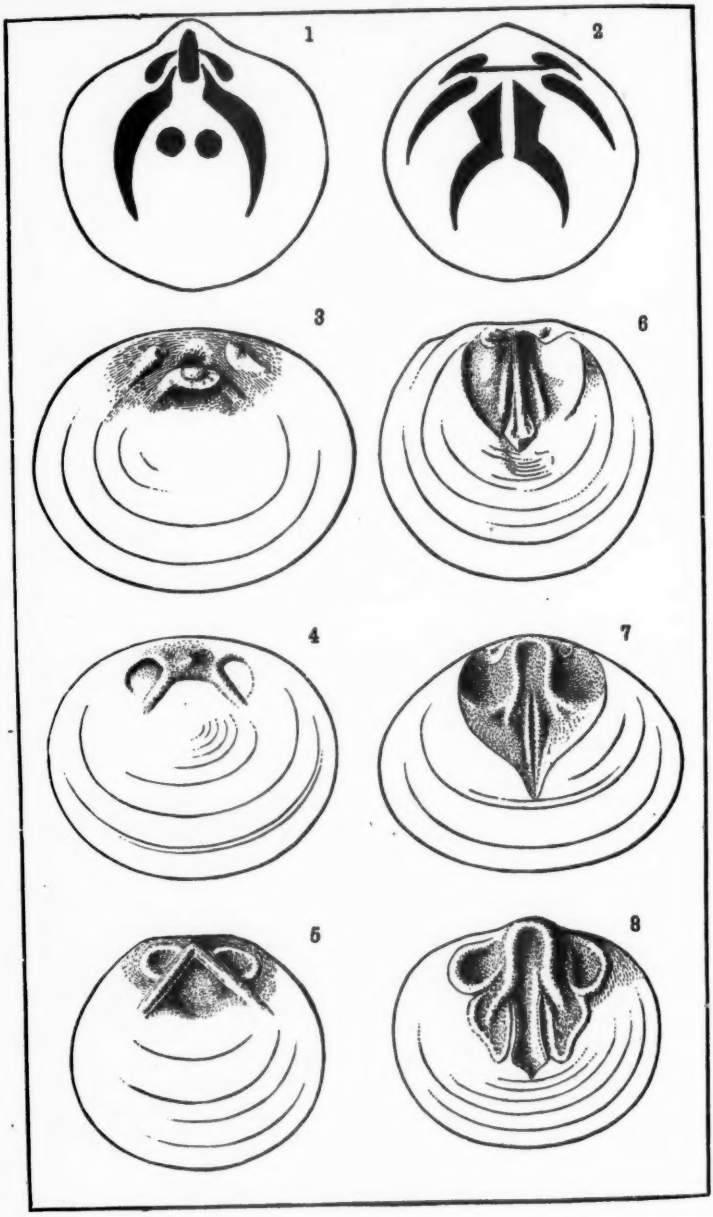
In an almost identical form Mr. Linnarsson* found the ventral valve to be perforated, and also describes a pedicle groove that, as yet, we fail to find in *L. transversa*.

The Obolella-like form figured by Barrande and De Verneuil† has the ventral valve perforate, and appears to be closely related to the genus under consideration.

The plan of the interior of the ventral and dorsal valves of *Obolella chromatica* are given as in Mr. S. W. Ford's paper,‡ and the interiors of *L. transversa* from drawings from the types of the species.

In a future paper I will endeavor to bring together descriptions and illustrations of all the American Cambrian species of *Obolidæ*.

* Brach. Paradoxides beds of Sweden, 1876, pl. iii, figs. 36–41.
† Bull. Geol. Soc. France, 2d ser., vol. xvii, pl. viii, fig. 5.
‡ The genus Obolella. This Journal, vol. xxi, p. 131, 1881.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Discina Acadica Hartt is now referred to the genus *Stenotheca*. When examining specimens of *Stenotheca rugosa* Hall, sp., from the Georgian horizon at Troy, New York, in the collection of Mr. S. W. Ford, I noticed compressed specimens that are almost identical in appearance with the type of Professor Hartt's species now before me. Mr. R. P. Whitfield* called attention to this resemblance, believing that *D. Acadica* was the impression of a univalve shell of the genus *Palæacmea* or *Stenotheca*.

DESCRIPTION OF FIGURES.

Fig. 1. Plan of the interior of the dorsal valve of *Obolella chromatica* as determined by Mr. Billings. Fig. 2. Ditto of the ventral. Fig. 3. Outline of the interior of the ventral valve of *Linnarssonia transversa;* the apex of the triangular shaped projection in front of the foraminal opening is broken off. Fig. 4. Cast of the interior of the ventral valve of ditto. Fig. 5. Cast of the interior of the ventral valve of *L. sagittatis*, after Davidson. Fig. 6. Interior of the dorsal valve of *L. transversa*, as shown in a flattened specimen. Fig. 7. Cast of the interior of the dorsal valve of an uncompressed example of *L. transversa*. Fig. 8. Cast of the interior of the dorsal valve of *L. sagittalis*, after Davidson.

ART XIX.—*On the Rotation of the Equipotential Lines of an Electric Current by Magnetic Action*; by E. H. HALL, Instructor in Physics at Harvard College.

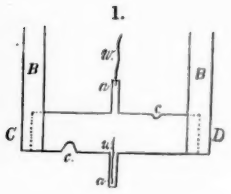
IN this article the results will be given of experiments made during the month of August, 1883, and at intervals since, in the Physical Laboratory of Harvard College. The substances which have been chiefly examined are copper, zinc, certain of their alloys, and iron and steel. Some mention will be made also of gold, cobalt, nickel, bismuth and antimony. In most cases when possible the metal was used in the form of a thin strip about 1·1 cm. wide and about 3 cm. long between the two pieces of brass B, B (fig. 1), which soldered to the ends of the strip served as electrodes for the entrance and escape of the main current. To the arms *a*, *a*, about 2 mm. wide and perhaps 7 mm. long, were soldered the wires *w*, *w*, which led to a Thomson galvanometer. The notches *c*, *c*, show how adjustment was secured. The strip thus prepared was fastened to a plate of glass by means of a cement of beeswax and rosin, all the parts shown in the figure being imbedded in and covered by this cement, which was so hard and stiff as to be quite brittle at the ordinary temperature of the air.

The plate of glass bearing the strip of metal so imbedded was, when about to be tested, placed with B, B, vertical in the narrow part of a tank whose horizontal section is shown in fig. 2. This tank T T containing the plate of glass with the metal

* Bull. Amer. Mus. Nat. Hist., vol. i, p. 140.

strip was placed between the poles P, P, of the electromagnet. The tank was filled with water which was sometimes at rest and sometimes flowing. By this means the temperature of the strip of metal was under tolerable control and the inconvenience from thermoelectric effects at a and a considerably lessened. The diameter of the plane circular ends of the pole pieces P, P, is about 3·7 cm.

1.



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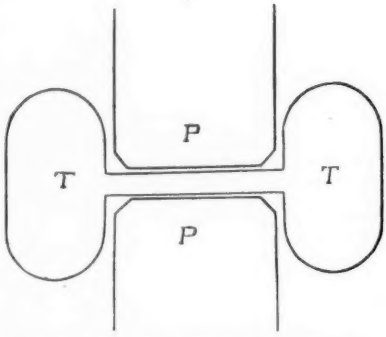

The general method of most of the experiments to be mentioned did not differ much from that described in this Journal for September, 1880. The intensity of the magnetic field was estimated as before, by the impulse given to a galvanometer needle when a small coil in connection with the galvanometer was suddenly removed from the field. This impulse was compared with that given to the same needle by the current obtained by turning an earth inductor of known dimensions.

The direct current through the strip under examination was measured by means of a tangent galvanometer. The transverse current was measured by means of a Thomson galvanometer, the reduction factor of this instrument usually being determined by passing through it a current of known strength a few minutes before and a few minutes after each set of observations on the transverse current.

The rotational powers will, then, be given in ostensibly absolute measure, but an uncertainty of several per cent attaches to the values given owing to uncertainty in regard to the following quantities: 1st, the thickness of the strips examined; 2d, the dimensions of the small test coil used for getting strength of magnetic field; 3d, the horizontal intensity of the earth's magnetism; 4th, the reduction factors of the tangent galvanometer used; 5th, the magnitude of the direct effect exerted by the electromagnet upon the Thomson galvanometer at a distance of about 50 feet.

One of the most troublesome operations in these experiments is that of determining the thickness of the metal strips examined. Owing to the inevitable slight roughness of the surface, direct measurement with calipers is likely to give too great a thickness. On the other hand the density of many specimens is subject to considerable uncertainty and, therefore, the indirect method by means of weight and density, which is the method used, cannot be applied with full confidence. Moreover the latter method gives, at best, only the average thickness of the strip, whereas I have heretofore assumed, and in this article still assume, that the effective thickness of the strip is the thickness of that part which lies between the two arms *a*, *a*. My practice of late has been, therefore, to determine the average thickness by the weight and density method, making use of the best data available, and to estimate the thickness between the arms by adding to, or subtracting from the average thickness, according as the calipers indicated the thickness at that place to be greater or less than the average. In case of several of the strips to be mentioned hereafter this correction was somewhat carelessly made and there may be an inaccuracy of four or five per cent in the estimated "effective thickness." With other strips much care was taken in this respect and it is believed that the uncertainty in regard to the density of the metal is the greatest source of error in determining the thickness in these cases. Particulars will be given as the strips are in turn described.

The 5th source of error was very troublesome in the experiments upon certain alloys. The galvanometer was unfortunately so placed that not only the magnitude but even the direction of this effect of the electromagnet might be varied when by any means the galvanometer needle was turned a few degrees from its ordinary position of rest.

Copper, Zinc and their Alloys.

More than three years ago (B. A. Report, 1881), I found that if the rotational power of copper is called −, that of zinc is +. At the same time a specimen of brass, exact composition unknown, had been found to lie between copper and zinc in this respect, but nearer the copper, having in fact a small − rotating power.

Through the kindness of Prof. Trowbridge and Mr. E. K. Stevens, I had at command in the summer of 1883 several alloys of copper and zinc in widely varying proportions. Specimens of these alloys had been analyzed chemically by Mr. Stevens, but as they had lain for some time in an exposed position after he had finished his work upon them, I feared the

labels upon them might not be intact, and Mr. G. D. Moore of the Harvard class of 1884 has been kind enough to make new analyses for me, determining both the copper and the zinc in specimens furnished him in the form of thin strips such as were used in my own experiments. Mr. Moore found

Specimen.	Copper.	Zinc.
A	99·9 per cent.	----
B	81·08	18·51 per cent.
C	72·86	27·02
D	66·85	33·04
F	5·87	93·79
G	a trace	99·54

Specimen E which contained apparently about 50 per cent copper was so brittle that I did not succeed in getting it rolled into a thin sheet.

Most, if not all, of these specimens were annealed one or more times during the process of rolling. None of the strips examined, however, were annealed after the final rolling. All of the strips which were used were cut in such a way that the arms a, a extended in that direction in which the strips passed through the rolls.

As it is a somewhat troublesome matter to determine accurately the density of a thin strip of metal and as my immediate purpose did not demand great accuracy in this respect, it seemed allowable to estimate the density of the alloys from their composition. After certain rough experiments the density 8·9 was assumed for the copper, and 7·2 for the zinc. Assuming, what we know to be not strictly true, that the density of an alloy decreases regularly as its amount of zinc per unit mass increases, we find

Alloy.	Density.
B	8·6
C	8·4
D	8·3
F	7·3

The description of particular strips will now be given.

A. (No. 1.)

Length of main strip when weighed	4·20 cm.
Width of main strip when weighed	1·07 cm.
Area including that of the arms	4·98 cm. sq.
Weight	·202 grm.
Density	8·9
Average thickness from above	·00456 cm.

By calipers the thickness appeared to be at one end ·0046; other end ·0044; between arms ·0048; average ·0046. Take then for true thickness between arms ·00476.

The measurement with calipers in this case was not made with great care, and the correction here applied is open to some suspicion.

With this strip the space between the brass strips B, B (fig. 1) was about 3·2 mm.

B. (No. 1.)

Length of main strip when weighed	4·58 cm.
Width of main strip when weighed	1·08 cm.
Area, including that of the arms	5·32 cm. sq.
Weight	·184 grm.
Density	8·58
Average thickness from these data	·00403 cm.

From the indications of the calipers I concluded that the thickness between the arms was about 1½ per cent greater than the average thickness.

Hence thickness between the arms, ·00409 cm. This value, like that given for A, may be wrong to the extent of several per cent. Distance between strips B, B, about 3·2 cm.

C. (No. 1.)

Length of main strip when weighed	3·75 cm.
Width of main strip when weighed	1·08 cm.
Area of whole strip when weighed	4·39 cm. sq.
Weight	·1085 grm.
Density	8·44
Average thickness from these data	·00292 cm.

By calipers thickness at one end, ·0034; at other end, ·0032; between arms, ·0034; average, ·00333 cm. Take then for true thickness between arms ·00299 cm. Distance between strips B, B, about 3·2 cm.

D. (No. 1.)

Length of main strip when weighed	3·86 cm.
Width of main strip when weighed	1·07 cm.
Area of whole strip	4·45 cm. sq.
Weight	·1081 grm.
Density	8·33
Average thickness from these data	·00291 cm.

By calipers thickness at one end, ·0030; at other end, ·0030; between arms, ·0032; average, ·00307 cm. Take for true thickness between arms ·00304 cm. Distance between strips B, B, about 3·2 cm.

F. (No. 1.)

Length of main strip when weighed	3·70 cm.
Width of main strip when weighed	1·06 cm.
Area of whole strip when weighed	4·28 cm. sq.
Weight	·2915 grm.
Density	7·3
Average thickness from the data	·00934 cm.

By calipers thickness at one end, ·0098; at other end, ·0100; between arms, ·0100; average, ·00993 cm. Take for true thickness between arms ·00941 cm. Distance between strips B, B, about 3·2 cm.

G. (No. 1.)

Length of main strip when weighed	4·17 cm.
Width of main strip when weighed	1·09 cm.
Area of whole strip when weighed	5·03 cm. sq.
Weight	·1206 grm.
Density	7·2
Average thickness from these data	·00333 cm.

From a somewhat careful use of the calipers it appeared that the thickness between the arms was about 4½ per cent greater than the average thickness.

Take then for thickness between arms ·00348 cm. Distance between strips B, B, about 3·2 cm.

The main object in the experiments upon these metals and their alloys was to determine whether the alloys would range themselves according to any simple law so that the magnitude of the rotational power in any alloy might be inferred from its known proportions of copper and zinc. Some attempt was made, moreover, to determine the effect of change of temperature in different specimens.

It will be seen that the intensity of the magnetic field was kept nearly the same throughout the experiments of August upon copper, zinc, and their alloys. The strength of the direct current was, moreover, of about the same magnitude in all cases except the experiments of Aug. 11th on copper. On that day the current used was less than one half as strong as that used later. The same strip of copper was tested again Aug. 29th with a current of the usual strength and the agreement between the results obtained under so widely different conditions is quite close.

In the following table and throughout this article the C. G. S. system is used wherever no statement is made to the contrary. The following symbols used with the tables need explanation:

C means current along line C D (fig. 1).

M means intensity of magnetic field perpendicular to plane of paper in fig. 1.

R. P. means *rotatory power*, which is numerically defined by the expression $D\frac{E}{C \times M}$, in which D is the thickness of the metal strip, and E is the electromotive force resulting from C and M which maintains the *transverse* current.* The R. P. is considered *positive* when E is of such a character as to send a *positive* transverse current in that direction in which the conducting strip tends to move under the action of the main current and the magnetic force.

The temperatures referred to in the tables are those indicated by a thermometer placed in the water tank containing the plates when under examination (fig. 2).

Copper, Zinc, and their Alloys.

Strip.	Composition &c. to chem. anal. Percent Copper.	Percent Zinc.	Date.	Tem.	M	C	R.P. $\times 10^{15}$	R. P. near 24° C $\times 10^{15}$	Composition, etc.† P. c. Cop.	P. c. Zinc.
	100		1883.							
A	(99·9)		Aug. 11	3°C.	5700	·0619	(−521)			
"	"		"	4·8°	5640	·0819	(−530)			
"	"		"	21·5°	5560	·0876	(−520)	(−520)		
"	"		Aug. 29	24·5°	6030	·1906	(−519)			
	81·3	18·7								
B	(81·08)	(18·51)	Aug. 18	25°	5750	·1800	(−404)	(−404)	91·3	8·7
	73	27								
C	(72·86)	(27·02)	Aug. 17	5·1°	5680	·1810	(−246)			
"	"	"	"	22·8°	5700	·1830	(−250)	(−250)	80	20
	67	33								
D	(66·85)	(33·04)	Aug. 13	6°	5830	·1680	(−178)			
"	"	"	"	25°	5930	·1680	(−166)	(−166)	73.6	26·4
	6	94								
F	(5·87)	(93·79)	Aug. 17	4°	5640	·1790	(+527)			
"	"	"	"	24°?	5690	·1780	(+496)	(+496)	24·3	75·7
	0·0	100								
G	(trace)	(99·54)	Aug. 15	4·4°	6150	·1860	(+838)			
"			"	25°	6130	·1850	(+830)	(+820)		
"			"	22·4°	6210	·1870	(+809)			

This table shows the results of experiments with the metal strips thus far described in detail. The last two columns give

* The R.P. of this article is the *reciprocal* of the quantity $\frac{M \times V}{E'}$ used in my article in the Amer. Jour. of Science, Sept. 1880.

† Composition of alloys which *à priori* might have been expected to have these values of R. P.

approximately the composition of plates which would have the observed rotatory powers if copper and zinc in uniting retained their individual powers unaltered. It will be perceived that in every case the proportion of copper demanded upon this basis is greater than the proportion in the actual plate.

At the time these experiments were made I supposed plate B to contain about 92 per cent of copper, which would have furnished an exception to this rule. Thinking some serious error might have been made in estimating the thickness of this plate, or that of the copper plate or the zinc, I prepared with very great care plates No. 2 of A, B and G. These new plates were similar to those already described, but were in length between B and B about 2·2 cm. As the vacation was now over and my opportunities for experimental work were limited, I contented myself with making, in the main, comparative experiments with these plates. I did not redetermine the horizontal intensity of the earth's magnetism and I made no attempt to determine the direct effect of the electromagnet upon the Thomson galvanometer with which the transverse current was observed. I knew that this direct effect was small and I endeavored to arrange matters in such a way that it would affect all the new results with A, B and G in the same direction and to nearly the same extent. The intensity of the magnetic field in the experiments with these plates was about the same as in the previous experiments with the alloys. This intensity was determined as usual on October 20th, when the effect of change of temperature upon the plate B No. 2 was tested, but on October 13th, when A No. 2 and B No. 2 were compared, and on October 27th, when A No. 2 and G No. 2 were compared, this determination was not considered necessary. On October 13th A No. 2 was tested first, then B No. 2, then A No. 2 again. This arrangement tended to make the result of the comparison independent of any progressive diminution in the strength of the current operating the electromagnet, and it saved much time. On October 27th the same method was followed.

I shall not attempt to give the result of these experiments in absolute measure, but shall write the results obtained on an arbitrary scale.

Specimen.		Per cent of Copper.	Per cent of Zinc.	Temp.	R. P.
A.	No. 2.	99·9	----	....	100(−)
B.	"	81·08	18·51	21°	76·1(−)
"	"	"	"	4°	78·7(−)
G.	"	....	99·54	....	158·8(+)

A No. 2 and B No. 2 were compared at about 25° C., A No. 2 and G No. 2 at about 19° C.

The values of R. P. given in the first table are in the following proportion:

		R. C.
A	No. 1.	100 (−)
B	"	77.6 (−)
C	"	157·5 (+)

This agreement was regarded as highly satisfactory, all things considered, and the apparent exception which, as stated above, had been noted in the case of B appeared to be confirmed. The result of the chemical analysis, however, showed that this alloy, which according to the label found upon it contained nearly 92 per cent of copper, really had the composition given in the tables above. Alloy B, then, does conform to the rule that the alloys of copper and zinc have rotating powers nearer to that of copper than the composition of the alloys would have led one to expect.

Influence of Temperature.

It will be seen that in the case of copper, zinc and all the alloys except C, a fall of temperature appears to cause a slight increase in the numerical value of of the rotating power. It is possible that upon further trial the apparent exception furnished by C would disappear. It does not, on the other hand, seem probable that the agreement in a particular direction of five cases out of six is entirely accidental. In the case of D the apparent change caused by fall of temperature is very considerable, but the observations made with this alloy were particularly unsatisfactory, the needle of the Thomson galvanometer being quite unsteady, while the total effect to be measured was small.

The experiments upon iron and steel were in the main repetitions of those already published, but made with more care.

Soft Iron.

The dimensions of the strip of soft iron used in the experiments were roughly as follows:

Length between terminals B, B, (fig. 1),	2·9 cm.
Width,	1·06 cm.
Thickness,	·0041 cm.

Like the strip used in 1882* it was obtained through the kindness of Prof. Langley of the Allegheny Observatory, and the two strips had probably nearly the same composition and character.

* This Journal, March, 1883.

Although the test made in 1882 was not satisfactory, it seemed to me to indicate that the R. P. of soft iron was slightly greater at high than at low magnetic intensities, and I hazarded the opinion that future experiments would prove this to be the case. This opinion has scarcely been justified by the result. The table given below does indeed appear to indicate a very slight increase in the R. P. as M rises from 801 to 3264 and again as M rises from 3264 to 5835, but the increase in the numbers as observed is too slight to deserve any confidence.

Date.	Temp.	M.	C.	R.P.	Estimated R.P. at 28°.
Aug. 22, '83.	6·2°	791·4	·1771	$+7147\times10^{-15}$	
"	28·2	797·6	·1742	+8302	
"	28·3	804·6	·1794	+8304	
	28·25	801·1		8303	$+8290\times10^{-15}$
Aug. 23.	28·1	3259	·1728	8306	
"	28·4	3274	·1702	8289	
"	27·65	3260	·1696	8306	
	28·05	3264		8300	$+8297\times10^{-15}$
Aug. 24.	28·7	5797	·1839	8391	
"	28·1	5833	·1842	8310	
"	28·0	5875	·1853	8245	
	28·27	5835		8315	$+8300\times10^{-15}$
Aug. 27.	27·25	8626	·1894	8139	
"	28·35	8690	·1898	8261	
"	27·95	8636	·1911	8200	
	27·85	8651		8200	$+8208\times10^{-15}$

Fall of R. P. for 1° fall of temperature equals approximately $\frac{2}{3}$ per cent.

On the other hand the decrease in the observed value of the R. P. as M rises from 5835 to 8651, though slight, seems to me strong evidence of an actual falling off in the value of the R.P. of iron at high magnetic intensities.

In any case it appears, and this was one of the important questions to be answered by the experiments, that the R. P. of iron under magnetic forces of varying intensity is more nearly constant than the R. P. of nickel, for according to previous experiments* the R. P. of nickel in a magnetic field of intensity 8700 is many per cent, perhaps 20, less than in a magnetic field of intensity 2000.

The one trial made at low temperature confirmed the inference drawn from a similar trial made the year before,† that a fall of 1° C. diminishes the R. P. in soft iron about $\frac{2}{3}$ per cent. It is with these experiments as a basis that I have ventured to

* Phil. Mag., Sept., 1881. † This Journal, March, 1883, p. 218.

make the slight changes necessary to deduce from the observed results the values of the R. P. at 28°.

A test was made with this strip of soft iron for a permanent change in the direction of the equipotential lines. A similar experiment with tempered steel the year before had been successful and the description of the method I will quote from a previous article (this Journal, March, 1883). "This plate, with the usual electrical connections, and with a current flowing through it, was placed in the usual position between the poles of the electromagnet, the magnet current was turned on, then off, and the plate removed from between the poles in order to avoid the action of the very considerable residual magnetism of the electromagnet. A reading of the Thomson galvanometer in the transverse circuit was now made, then the plate was replaced between the poles and the current turned on again but in the opposite direction. The magnet current being again interrupted, the plate was again removed from the field and another reading of the Thomson galvanometer was made." Making this experiment with the soft iron and with a battery of 50 cells, the result was a negative one. If any permanent effect was produced, it was probably a small part of one per cent of the temporary effect produced while the plate was subjected to the magnet's action.

Steel.

The steel used in this series of experiments was obtained from Montgomery & Co., New York, and was designated by the letters "F. C. R." which stand for "French Cold Rolled." This steel as it came from the dealers was pliable and soft enough to be quite readily cut with a pocket knife. The first strip to be described was tested in this "natural" condition.

No. 1 (*untempered.*)

Length of main strip when weighed	4·15 cm.
Width of main strip when weighed	1·10 cm.
Area of whole strip when weighed	4·88 sq. cm.
Weight	4·21 grm.
Density	7·9
Average thickness from these data	·01092 cm.
Estimated thickness between arms	·01116 cm.
Distance from B to B, about	3·1 cm.

No. 2 (*tempered.*)

The dimensions of this strip were not so carefully taken. It was so brittle that I felt obliged to use caution in applying the calipers to it. It appeared to be of about the same thickness as No. 7 and I assumed it to have exactly the same thickness. The distance from B to B was about 2·6 cm.

Results obtained with these two strips are shown in the following table:

	Date.	Temp.	M.	C.	R.P.
No. 1.	Nov. 24.	18·7°	1647	·0970	$+12000\times10^{-11}$
"	"	2·5	1629	·1007	$+11230\times$ "
		16·2			770

Decrease for 1° fall of temperature, approximately ·4 per cent.

No. 2.	Dec. 1.	18·°	1602	·0870	$+32720\times10^{-11}$
"	"	1·9	1587	·0908	$+30800\times$ "
		16·1			1920

Decrease for 1° fall of temperature, approximately ·4 per cent.

The magnitude of the rotational coefficient in the soft steel is about $1\frac{1}{2}$ times, and that in tempered steel about 4 times as great as that in the soft iron. This agrees very well with the conclusion drawn from the hasty experiments of the year before, when a piece of steel from a clock-spring was used. When a sensitive galvanometer is used, an ordinary permanent horse-shoe magnet of half inch bar produces an easily discernible effect in the strip of tempered steel.

It should be stated that two or three months before the trials which furnished this table were made, both these steel strips had been subjected, in the usual position, to a magnetizing force of about 8500 intensity. It does not seem probable that the results just recorded were seriously affected by this previous experience of the steel.

This first magnetization was for the purpose of detecting, if possible, a *permanent* effect, such as had been observed a year before in a piece of tempered clock-spring, but had been vainly looked for in soft iron.

No. 2 showed a permanent effect equal to about $1\frac{1}{2}$ per cent of the temporary effect, a result agreeing very well with that obtained with the tempered clock-spring. No. 1 showed a permanent effect relatively, and even absolutely, larger than that in No. 2. It was about 5 per cent of the temporary effect. In both cases the tests made were hasty, and the results obtained are only approximately correct. I believe it has been observed that residual magnetization is, under certain conditions, greater in soft than in hard steel.

Gold.

The only experiment of importance made with gold was a test for permanent effect. The strip used was the one experimented with the year before, a description of which has already been published (this Journal, March, 1883). The permanent effect, if any was produced, must have been a very small part of one per cent of the temporary effect.

Cobalt.

In the Philosophical Magazine for September, 1881, I said, "No thin strips of the metal [cobalt] being at hand, a slice was sawn from a small block of moderately pure cast cobalt and worked into the form of a cross. To the extremity of each arm of this cross was soldered a thin strip of copper . . . . for the purpose of making the electrical connections. The cross of cobalt with the copper strips attached was now fastened with hard cement [beeswax and rosin] to a strip of glass," etc. It was the same piece of cobalt, reduced now with file and emery paper to a thickness of about ·0062 cm., that served during this new series of experiments. The central portion of the cross was about 2 mm. square, and the arms, about 3 mm. long and 2 mm. wide, projected from it at right angles.

The main object of the recent test was to determine the effect produced in cobalt by change of temperature. It is assumed that the intensity of the magnetic field remained constant during these experiments. It is possible, however, that it diminished one or two per cent during the series. The error introduced in this way is of slight consequence for the present purpose. Again, the direct effect of the electromagnet in disturbing the needle of the Thomson galvanometer was neglected, together with certain other particulars which may have introduced a constant error of several per cent into the values obtained for the rotatory power.

No. of Exp.	Date.	Temp.	M.	C.	R.P.
1.	Dec. 22, '83.	3°	3463	·1251	$+2092\times10^{-10}$
3.	"	1·3°	"	·1243	+2061
		2°			2076
2.	"	18°	"	·1238	+2441
4.	"	"	"	·1244	+2390
		18°			2415

Decrease of R. P. for fall of 1° C. is approximately $\frac{8}{10}$ per cent.

Bismuth.

I can only confirm what Prof. Righi* has already published concerning the rotational effect in this metal. The rotational power appeared to be about 260 times as great numerically as that of tempered steel and of the opposite sign.

The slice of bismuth used was obtained, shaped and mounted in much the same manner as the slice of cobalt already described. The length and breadth of the bismuth cross were somewhat greater than the corresponding dimensions of the cobalt and the thickness was about 1 mm.

* Acc. dei Lincei Transunti, June, 1883.

It seems probable that a thin slice of bismuth, properly prepared and mounted, will come to be a valuable instrument for measuring the intensity of strong magnetic fields.

Antimony.

The powerful effect observed in bismuth suggested an examination of antimony. A slice of this metal much like the slice of bismuth just mentioned was prepared. The cross suffered in shape a good deal in making the adjustment. The final average thickness in the central portion was estimated at 1·2 mm.

Date.	Temp.	M.	C.	R.P.
1884, July 26th,	21·8°	1696	·1150	$+114100\times10^{-10}$
Aug. 8th,	21·1°	1638	·1104	$+117300\times$ . . .
Aug. 8th,	3°	1638	·1104	$+123900\times$ . . .

The two trials of August 8th were not entirely independent of each other, as only one test of the intensity of the magnetic field and of the sensitiveness of the Thomson galvanometer was made during the two trials of that date. The results as they stand indicate an increase of the rotational power with fall of temperature, but the experiments were too hasty to justify a conclusion upon the matter.

Several experiments have resulted from the criticisms or suggestions of other investigators.

Mr. Bidwell's Theory.

This has been so recently and so widely published that it is hardly necessary for me to state it in detail.

In *Science* (March 28th, 1884), I replied very briefly to Mr. Bidwell's first paper, stating that I found the transverse current in a strip of soft steel to be in the same direction when the strip was fastened to the supporting plate by a clamp across the middle of the strip only, as when it was fastened by means of clamps at its ends only.

Mr. Bidwell has in his second paper (Phil. Mag., April, 1884), described an experiment which he appears to consider conclusive against the previously accepted view of the "rotational effect." In brief he obtains what he calls a "reversal" of the transverse effect in gold, using a strip of that metal having two narrow longitudinal slits lying on the same straight line and nearly meeting in the center of the strip.

I shall not undertake here an extended discussion of this interesting experiment of Mr. Bidwell. My view of the matter is in substance as follows:

Let *l* in fig. 3 represent an equipotential line in a strip of metal through which an electric current is flowing, the metal being in a normal condition.

In fig. 4, *l* represents the corresponding equipotential line when the metal strip is acted upon by a powerful magnetic force in a direction perpendicular to the plane of the paper.

If now *a* and *b* be connected by means of a wire, a current will flow from *a* to *b* through the wire. If *a'* and *b'* be connected in the same way, a weaker current will flow from *a'* to *b'* through the wire.

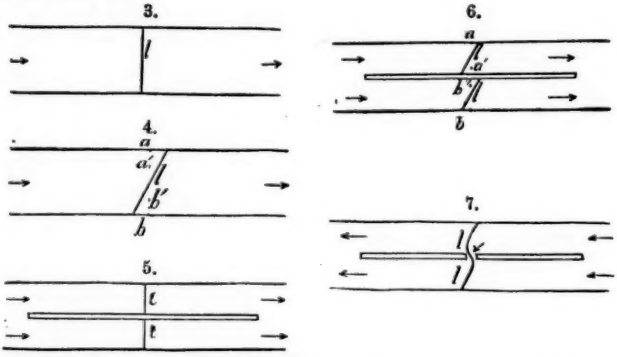

Fig. 5 represents a metal strip having along its middle a slit longer than the diameter of the magnetic poles between which the slit is placed, *l* and *l* being corresponding equipotential lines when the strip is in its normal unstressed condition.

Let a magnetic force act as before. Each of the lines *l*, *l* in fig. 5 is rotated about its center through the same angle as *l* in figs. 3 and 4. The result is shown in fig. 6.

If now *a* and *b* be connected by means of a wire a current will flow from *a* to *b* through the wire. If *a'* and *b'* be connected in same way a current will flow from *b'* to *a'* through the wire.

To get Mr. Bidwell's case, imagine a narrow bridge of metal to be left crossing the slit between *a'* and *b'*. Such a bridge would serve as a shunt to the wire which we have imagined connecting *a'* and *b'* but would not reverse the relative potentials of these two points. The lines *l*, *l*, as Sir Wm. Thomson pointed out at the Philadelphia meeting, would now take a form something like that shown in fig. 7.

As the bridge across the slit becomes wider such lines as *l* will become more nearly straight till finally the condition of things represented in fig. 4 will be practically reproduced. On the other hand if the slit in fig. 5, were short compared with

the width of the poles of the magnet, a *reversal* such as Mr. Bidwell detected should not occur.

Mr. Tomlinson's Suggestion.

In the Philosophical Magazine for May, 1884, Mr. Tomlinson stated that certain relations which he had discovered indicated that the rotational effect in nickel should be greater at low than at high temperatures. He therefore called in question the conclusion to the contrary which I had drawn from certain hasty and very rough experiments made before the use of the water tank gave me the means of easily controlling the temperature of the metal under examination. I have, therefore, recently taken up the matter again. I used the same piece of nickel with which the former test was made (Phil. Mag., Sept., 1881, p. 163), but the strip was now so much damaged while being fastened upon glass that it was necessary to cut its width down a good deal in order to obtain the "arms" for the side connections. The following table shows the results obtained.

No. of exp.	Date.	Temp.	M.	C.	R.P.
1	July 28, '84.	22°	1717	·03074	14940×10^{-15}
2	"	4·9°	1703	·03135	13760 "
3	" 29,	20·5°	1652	·03140	14710 "
4	" 30,	2·2°	1636	·03123	12810 "
5	" "	21·2°	1629	·03121	15060 "
6	Aug. 1,	2·8°	1671	·03137	13180 "
7	" 4,	26·1°	1691	·03140	15110 "
8	" "	4·1°	1627	·03112	13220 "

Combining the 1st, 3d, 5th and 7th, we have

Temp.	R.P.
22·5°	14960×10^{-15}

From the 2d, 4th, 6th and 8th we have

3·5°	13240×10^{-15}

Decrease for 1° fall of temperature = approximately .6 per cent.

It will be noticed that the results obtained at low temperatures do not accord so well as those at high temperatures. This fact is in all probability due to the difficulty experienced in preventing slight fluctuations of temperature while the colder water was flowing through the tank. Irregularity in the flow of this water causes disturbing thermo-electric currents.

The quantity called R. P. in this paper corresponds to the $\frac{E'}{V}$ of my 1881 paper divided by the F of that paper. Calculating the R. P. of nickel from the 188 experiments I find it to

be about 12700×10^{-15}, for a field of intensity 1660. In looking about for an explanation of this disagreement I found that the thickness of the strip had been called ·00104 cm. in 1881, and ·0012 cm. in the later experiments. The former estimate was obtained by weight, the latter by measurement with calipers. The difference accounts well enough for the different values obtained for the R. P. Which estimate of the thickness is the more reliable I will not undertake to decide.

Summary.

	$10^{15} \times$ R.P. at 20°C.
Copper	−520
Zinc	+820

Four alloys of copper and zinc were tested. If a series be made beginning with zinc and ending with copper, the four alloys being ranged between according to composition, the series thus formed will be the same as that obtained by ranging these metals and alloys according to the algebraic magnitude of their R. P's. In the alloys, however, the R. P's, are algebraically somewhat nearer that of copper than might be expected from the composition.

Iron ..... +7850

R. P. nearly constant through wide range of magnetic intensity but apparently decreasing slightly at high intensities.

No ascertained *permanent* effect.

Steel, *soft* ..... +12060

Permanent effect about 5 per cent of temporary effect.

Steel, *tempered*, ... +33000

Permanent effect about $1\frac{1}{2}$ per cent of temporary effect.

Gold (no new test of magnitude of R. P.) .. −660

No ascertained permanent effect.

Cobalt	+2460
Nickel	−14740
Bismuth	−8580000
Antimony	+114000

A fall of 1° C. in temperature causes

in the R.P. of Iron,	a fall of	$\frac{2}{3}$	per cent approx.
Steel, soft,	"	$\frac{1}{3}$	"
Steel, temp'd,	"	$\frac{1}{3}$	"
Cobalt,	"	1	"
Nickel,	"	$\frac{2}{3}$	"

Non-magnetic metals, apparently a small increase.

Appendix.

At the Philadelphia meeting of the American Association I stated that I had compared the behavior of a strip of soft steel cemented to a plate of glass with that of a similar strip fastened to a plate by means of a clamp. In preparing the matter for publication, however, I found that the test had not been made so carefully as was desirable, and I have therefore just repeated the experiment with the assistance of Mr. W. A. Stone, of the Harvard class of 1886.

I shall call the cemented strip A. It has been already mentioned as No. 1 in the preceding article. The clamped strip I shall call B. Both strips were cut from the same sheet of soft steel. Each is about 1·1^{cm} wide and 3·2^{cm} long between the terminals of brass. A is about ·011^{cm} thick and possibly a few per cent thicker than B. A suffered rather more than B in the process of adjustment (fig. 1).

A was not only fastened to its plate with the cement of beeswax and resin, but was imbedded in the cement, the latter covering it with a layer probably a millimeter or more in thickness. The plate was not placed in water for this test. The bearing of the clamp which fastened B to its plate was of wood, possibly a millimeter wide, and extended nearly from arm to arm of the strip. To prevent any very great bending each end of the strip was loosely tied to the plate with a piece of twine. Otherwise the strip was free and was exposed to the air.

The measurements recorded below were made between five and six o'clock, January 17th. There was an interval of one minute between successive readings of the Thomson galvanometer. No measurement of the intensity of the magnetic field was made. It is assumed that this intensity during the one trial of A, which was made between the two trials of B, was equal to the mean intensity during these two trials.

The signs + and − refer to the direction of magnetization, R and L to direction from the zero point of the Thomson galvanometer scale. The zero position of the index in these experiments was a considerable distance to the right of the zero of the scale. The tangent galvanometer measured the direct current through the strip.

	Thomson Galv.		Tangent Galv.
			74·0°
	+	−	73·9
	53 R		73·7
Strip B.	52 "	0	73·7
	51 "	3 R	73·6
	52 −	1·5 = 50·5	73·8, tan. = 3·44

				74·9°
				74·8
	43 R			74·7
Strip A.	43 "	8·0 L		74·7
	43 "	6·5 "		74·6
	43	+ 7·2	= 50·2	74·7, tan. = 3·66
				73·7°
				73·6
	54·5 R			73·5
Strip B.	53·0 "	7·0 R		73·4
	52·5 "	7·5 "		73·3
	53·3	− 7·2	= 46·1	73·5, tan. = 3·38

From 2d we have

$$\text{A.} \qquad 50{\cdot}2 \div 3{\cdot}66 = 13{\cdot}7$$

From 1st and 3d,

$$\text{B.} \qquad \frac{50{\cdot}5+46{\cdot}1}{2} \div \frac{3{\cdot}44+3{\cdot}38}{2} = 14{\cdot}2$$

Of course absolute agreement in so rough a test was not to be expected. The difference of about 3 per cent here observed might easily be accounted for. I think Mr. Bidwell will admit that his theory would have predicted a different result of the comparison.

Cambridge, January 19, 1885.

ART. XX.—*On the use of the term Esker or Kăm Drift;* by J. HENRY KINAHAN.

FROM the papers read at the British Association Meeting at Montreal it is evident that the American geologists classify, under the names of Eskers and Kăms, gravels that are not so classified in Ireland.

These two words are Celtic. Căm, Kăm or Kăme, should be pronounced short. Kāme, the lowland Scotch and English pronunciation, is incorrect. Curiously the English river Căm is pronounced right; while the town on it, usually, although not always, is pronounced wrong, Cāmbridge.

Căm or Kăm means *crooked* or *winding*. In Ireland and England this name is generally used in reference to a winding river; but in the former it is also sometimes used in reference

to winding ridges, or a winding or wrinkled structure; thus ophiolyte is called serpentine in English on account of its structure but in Ireland it is "Cămstone." This latter name for serpentine is now nearly obsolete, except in parts of Ulster, where an impure steatyte with a wrinkled structure is still called *Cămstone.*

Eiscir, pronounced Esker, is a well defined but small ridge. A nearly continuous ridge of gravel—Kăms—extends from Dublin to Galway, dividing Ireland into two nearly equal portions. This ridge, when Ireland, in the early historic period, was divided into two kingdoms, was taken as the divisional line; and hence the term Esker has generally been used in that country in place of Kăm, to designate the winding or crooked ridges of gravels, which in Scotland still retain commonly the more correct name of Kăm. Although in America the pronunciation Kām seems some way to have become general, yet, as far as my experience in Scotland goes, the word is generally pronounced Kăm.

True Esker or Kăm drift comprises more or less winding or crooked ridges and irregular hills of sands and gravels, due to the current and eddies generated by the meeting or colliding of two or more currents in a mass of water, such as that of a sea or large lake. Wind-driftage may also aid in forming esker sands, as for instance the long irregular ridges and hills constituting in many places the dividing ridge between a lagoon and a sea, where there is a rise and fall of tide: that is, a colliding of two or more currents;—in a tideless sea the enclosing materials of the lagoons are of a quite different nature from Esker or Kăm drift. In the dividing bars between a tidal sea and a lagoon the combination of the water and wind drifts are very interesting; high tides accumulating layers of gravel (fine or coarse) to be covered up by layers of fine sand due to the wind driftage.

The normal esker drift-ridges that are solely due to the colliding of currents in a mass of water, or those combined with wind-driftage, have a peculiar character of their own and should not be again confounded, as they were formerly, with other gravel and sand hills, such as the subaerial gravels on hill slopes, due probably to the water given off from a névé or mass of ice on a hill, during the summer; or the long regular ridges in valleys, due to excessive or sudden floods.

There are, both in the United States and the adjoining Canadian prairies, ridges of drift somewhat like the Irish Eskers, but at the same time totally different from them. What they are due to would be presumptuous in me to say, but they seem to be adjuncts of the great glacial moraines, because, as far as I was able to study them, they appear to be in connection with the breasts or marginal faces of such accumulations; as if for some

reason, to me unknown, there were at times "flashes," or areas of shallow water, accumulated margining the faces, portions of which were still water, while in other portions there were currents; or it might have been a mass of snow margining a narrow flash of flowing water. This latter suggestion is put forward on account of what can be seen, but on a very small scale, in some of the Irish mountains, but more largely in some of the valleys of the Canadian Rockies. If such is their origin they may be considered in part allied to true eskers.

The above notes are written because it appears that American observers are unwittingly confounding the true Esker drift with the others which are more or less similar; and as the writer was the first, or one of the first, who pointed out the very different, but in some cases, rather similar drifts, that were gradually being included under the terms, As or Ôsar, Esker, Cam, Kam, Kaim, Kame, all of which are names for the one and the same class of drift, he may perhaps be excused for drawing attention to the subject.

Esker or Kăm drift *par excellence* occurs in narrow, well defined, winding ridges, on a more or less level tract or area, and in such an area they are all on or at about one altitude, such as we might expect to find near the margin of a sea or large lake; while ridges of gravel running down a steep slope or the slope of a valley must necessarily have quite different origins. Up in valleys near their terminations, or in tributary valleys, there are other ridges that are very nearly allied to Eskers, they having originally been the marginal barriers of a lagoon; but if you take the outward appearance of true Eskers, combined with their peculiar internal structure, there is nearly invariably a marked difference between them and any other gravel accumulations. The writer of this has very fully gone into the subject of the Irish Eskers in a paper on "The Eskers of the Central Plain of Ireland," Dublin Geol. Soc., vol. x, or the Dublin Quarterly Journal of Science, vol. iv, and in the Geology of Ireland, Chap. xv, page 251, etc.

Ramelton, Co. Donegal, Dec. 10, 1884.

Art. XXI.—*On the Cause of Mild Polar Climates;* by James Croll, LL.D., F.R.S.

[Continued from page 29.]

Influences of Eccentricity during the Tertiary Period.—This being the state of things on the southern hemisphere, the glacial condition of the hemisphere, when its winter solstice was in aphelion, would tend in a powerful manner to impel the warm water of the south over on the northern hemisphere, and thus raise its temperature. This, again, is a view which has also been urged by Mr. Wallace. "Though high eccentricity would," he remarks, "not directly modify the mild climates produced by the state of the northern hemisphere which prevailed during Cretaceous, Eocene, and Miocene times,* it might indirectly affect it by increasing the mass of antarctic ice, and thus increasing the force of the trade-winds and the resulting northward-flowing warm currents. . . . . And as we have seen that during the last three million years the eccentricity has been almost always much higher than it is now, we should expect that the quantity of ice in the southern hemisphere will usually have been greater, and will thus have tended to increase the force of those oceanic currents which produce the mild climates of the northern hemisphere" (p. 192).

There is little doubt but that the climate of the Tertiary period was greatly affected by eccentricity; but, owing to the difference in the geographical conditions of the two hemispheres, eccentricity would exercise a much greater influence on the climatic condition of the northern hemisphere when the northern winter solstice was in perihelion than it would do when it was in aphelion. Owing to the difference in the conditions of the two hemispheres, the physical agents brought into operation by a high state of eccentricity would act more powerfully in impelling the equatorial waters toward the arctic regions when the winter solstice was in perihelion than they would do in impelling the waters toward the antarctic regions when the solstice was in aphelion. In this case the northern hemisphere would be heated to a greater extent when its winter solstice was in perihelion than it would be cooled when the solstice was in aphelion. It is this circumstance which, I think, has misled geologists, and induced them to conclude that because the physical agents brought into operation when the winter solstice was in aphelion, during a high state of eccentricity, failed to produce a well-marked glacial epoch in

* High eccentricity might not directly modify the mild climates, but certainly the physical agents brought into operation by the high eccentricity would do so.

Tertiary times, that consequently the climatic condition of that period was not much affected by eccentricity.

It would seem to be owing to that peculiar difference between the conditions of the two hemispheres that, even during high eccentricity, the physical agents in operation when the winter solstice was in aphelion were unable to lower the temperature of the northern hemisphere to the extent sufficient to cover high temperate and arctic regions with permanent ice; but for this very same reason these agents would be enabled to raise the temperature to an extent exceptionally high when the winter solstice was in perihelion. In other words, this very combination of circumstances, which so much modified the severity of what may be called the Tertiary cold periods, intensified to an exceptionally great extent the warmth and equability of what may be called the Tertiary warm periods.

Climate of the Tertiary Period, in so far as affected by the Eccentricity.—If the foregoing conclusions are correct, the following would then seem to be the probable character of the climate of the Tertiary period, in so far as that climate was affected by eccentricity. As is truly remarked by Mr. Wallace, the eccentricity during the past three million years has been almost always much higher than it is now. It will consequently follow that very considerable portions of the Tertiary age would consist of alternate comparatively cold and exceedingly warm and equable periods. These may be said to correspond to the cold and warm periods of the glacial epoch; but, of course, they could in no sense be called glacial and interglacial periods; for the cold of the cold periods would not be such as to produce permanent ice, while the heat and equability of the warm periods would far exceed that of the interglacial periods.

Evidence of such Alternations of Climate.—That such oscillations occurred during the Tertiary period seems to be borne out by the facts of geology and palæontology. Mr. J. Starkie Gardner, a geologist who has had great experience in the fossil flora of the Tertiary deposits, says that such alternating warmer and colder conditions is supported by strong negative and some positive evidence, found not only in English Eocene, but in all Tertiary beds throughout the world. In the Lower Bagshot of Hampshire have been found, he states, feather- and fan-palms, *Dryandra*, beech, maple, *Azalea*, laurel, elm, acacia, aroids, cactus, ferns, conifers, *Stenocarpus*, and plants of the pea tribe, together with many others. The question which presents itself to one's mind, he remarks, is, how is it possible that the tropical forms, such as the palms, aroids, cactus, etc., could have grown alongside of the apparently temperate forms, such as the oak, elm, beech, and others? Mr. Gardiner's explanation is as follows:—

"Astronomers, having calculated the path of the revolution of the earth in ages past, tell us that in recurring periods each hemisphere, northern and southern, has been successively subject to repeated cyclical changes in temperature. There have been for the area which is now England many alternations of long periods of heat and cold. Whenever the area became warmer, the descendants of semitropical forms would gradually creep farther and farther north, whilst the descendants of cold-loving plants would retreat from the advancing temperature, *vice versâ*. Whenever the area became gradually colder, the heat-loving plants would, from one generation to another, retreat farther and farther south, whilst the cold-loving plants would return to the area from which their ancestors had been driven out. In each case there would be some lingering remnants of the retreating vegetation (though perhaps existing with diminished vigor) growing alongside of the earliest arrivals of the incoming vegetation.

Such is a possible explanation of our finding these plant-remains commingled together. It must be borne in mind that it is not so much the mean temperature of a whole year which affects the possibility of plants growing in any locality, as the fact of what are the extremes of summer and winter temperature." *

This is precisely the explanation given by the commingling of subtropical and arctic floras and faunas of deposits belonging to the Glacial epoch. The causation in the two cases was in fact the same in principle, differing only in the conditions under which it operated. In the case of the Glacial epoch the cold periods were intensely severe and the warm periods but moderately hot; whereas in regard to the Tertiary cold periods they were but moderately cool, and the warm periods exceedingly hot.

Mr. Wallace, who refers to Mr. Gardner's views approvingly, says:—"In the case of marine faunas it is more difficult to judge, but the numerous changes in the fossil remains from bed to bed, only a few feet and sometimes a few inches apart, may be sometimes due to change of climate; and when it is recognized that such changes have probably occurred at all geological epochs, and their effects are systematically searched for, many peculiarities in the distribution of organisms through the different members of one deposit may be traced to this cause." †

To prevent having thus to admit the existence of alternate warmer and colder periods during Tertiary times, Mr. Searles V. Wood, Jun., proposed another theory, which, stated in his own words, is the following:—

"The remains upon which the determination of this flora have been based are drifted, and not those of a bed *in situ* like the coal seams, and the whole of the Hampshire Eocene is connected with

* Geological Magazine, 1877, p. 25. † Island Life, p. 197.

the delta of a great river which persisted throughout the accumulation of the various beds, which aggregate to upwards of 2000 feet in thickness. This river evidently flowed from the west through a district of which the low ground had a tropical climate; but like some tropical rivers of the present day, such as the Brahmaputra, the Megna, the Ganges, etc., it was probably fed by tributaries flowing from a mountain-region supporting zones of vegetation of all kinds from the tropical to the Arctic, if during the Eocene period vegetation such as the present Arctic had come into existence, of which we have as yet no evidence. Torrential floods may have swept the remains of vegetation from the temperate zones of this region into tributaries that conveyed it into the main river before it was decayed or water-logged, where it became intermingled with the remains of vegetation which grew in the tropical low ground skirting the main stream, so that both sank together into the same mud and silt."*

The elevated mountain regions from which he supposes these temparate forms were derived he thinks might have been Mull, 400 miles N.N.W., and Wales 200 miles N.W. Mr. Gardner, however, showed most conclusively that Mr. Wood's theory was based on imperfect acquaintance with the conditions of the problem. The following is Mr. Gardner's reply:—

"The leaves have never been drifted from afar; they are often still adhering to the twigs. The leaves are flat and perfect, rarely even rolled and crumpled, as dry leaves may be, if falling on a muddy surface; still more rarely have they fallen edgeways and been imbedded vertically. They are, moreover, not variously mixed, as they should be if they had been carried for any distance, but are found in local groups of species. For example, all the leaves of *Castanea* have been found in one clay patch, with *Iriartea* and *Gleichenia*; none of these have been found elsewhere. A trilobed leaf is peculiar to Studland; the Alum Bay *Aralia*, the peculiar form of *Proteaceæ*, the great *Ficus*, and other leaves occur at Alum Bay only. Each little patch at Bournemouth is characterized by its own peculiar leaves. Such a distribution can result only from the proximity of the trees from which the leaves have fallen. The forms of most temperate asepct are best preserved, so that to be logically applied, the Drift theory requires the palms, etc., to have been drifted upwards. To suppose that most delicate leaves could have been brought by torrents 400 miles from Mull or 200 miles from Wales, and spread out horizontally in thousands, without crease or crumple, on the coast of Hampshire, may be a feasible theory to Mr. Searles V. Wood, Jr., but will not recommend itself to the majority of thinkers."†

Were there Glacial Epochs during the Tertiary Age?—Many geologists, especially amongst those who are opposed to the

* Geological Magazine, 1877, p. 96. † Geological Magazine, 1877, p. 138.

theory of recurring glacial epochs, answer this question emphatically in the negative. This belief as to the non-existence of glacial conditions during the Tertiary period is, of course, based wholly on negative evidence; and this negative evidence though strong is by no means perfectly conclusive, and certainly not worthy of the weight which has been placed upon it. In Chap. xvii of 'Climate and Time,' I have endeavored to show that although much has been written on the imperfection of geological records, yet the imperfection of those records in regard to the past glacial epochs has not received the attention which it really deserves.

It must be borne in mind, however, that it does not follow from the Physical Theory of Secular changes of Climate, that because the eccentricity may have been high at some particular period there must necessarily have been a glacial epoch. The erroneous nature of this misapprehension of the theory has already been shown at considerable length.* Eccentricity can produce glaciation only through means of physical agencies, and for the operation of these agencies, a certain geographical condition of things is absolutely necessary. We know with certainty that during the Tertiary period the eccentricity was at times exceptionally high, as, for example, 2,500,000 and 850,000 years ago; but whether a glacial epoch occurred at these periods depended, of course, upon whether or not necessary geographical conditions then obtained. Supposing the necessary geographical conditions for glaciation did exist at the two periods in question, still if these conditions differed very much from those which now obtain, the glacial state of things then produced would certainly differ from that of the last glacial epoch. This is obvious, for the same physical agencies acting under very different conditions would not produce the same effects. Under almost any geographical condition of things eccentricity would produce marked effects, but the effects produced might not amount to glaciation. In the Tertiary age, during high eccentricity, the effects resulting might possibly have been as well marked as they were during the Glacial epoch; but these effects must have differed very much from those produced at that epoch. We have seen that, owing to that peculiar geographical condition of things existing during the Tertiary period, the physical agents brought into operation by a high state of eccentricity would have a much greater influence in *raising* the temperature of the northern hemisphere, when the winters occurred in perihelion, than they would have in *lowering* the temperature of that hemisphere when the winters were in aphelion. At the periods 2,500,000 and 850,000 years ago, for example, those physical agents would no doubt produce

* Phil. Mag., February, 1884; American Journal of Science, February, 1884.

quite a tropical condition of climate in high northern latitudes when the winters were in perihelion, while it is quite probable they may not have been able to produce glaciation when the winters were in aphelion. It is more than likely that the tropical nature of the climate during portions of the Tertiary period was due not so much to that peculiar distribution of land and water existing then, as it was to the fact that this peculiar distribution enabled the physical agents in operation during a high state of eccentricity to impel a vastly greater amount of warm intertropical water into the temperate and Arctic seas than they could have done under the present geographical condition of things.

Those very same geographical conditions enabling the physical agents to raise the temperature exceptionally high during the warm periods would, on the other hand, prevent them from being able to lower the temperature exceptionally low during the alternate cold periods. Nevertheless, I think it probable that as the two periods referred to, when the eccentricity was much greater than it was during the Glacial epoch, the temperature would be lowered to an extent that would produce glaciation, although the glaciation might not perhaps approach in severity to anything like that of the Glacial epoch. The negative evidence which has been adduced against the existence of such glacial conditions during the Tertiary period is certainly far from being conclusive.

The opinion is concurred in by Mr. Wallace that the Table of Eccentricity for the past three million years, given in 'Climate and Time,' probably includes the greater part, if not the whole, of the Tertiary period. He states that during the 2,400,000 years preceding the last glacial epoch there were, according to the table, no fewer than sixteen separate epochs when the eccentricity reached or exceeded twice its present amount. But it does not follow, according to the Physical Theory, that there ought, on that account, to have been sixteen epochs of more or less glaciation. Whether such ought to have been the case or not would depend on whether or not the geographical conditions were the same during these epochs as they were at the Glacial epoch; a thing regarding which the theory is not responsible. The question is not were there sixteen glacial epochs during the Tertiary period, but were there any? Even granted that those channels assumed by Mr. Wallace did exist, they would not, I feel assured, wholly prevent glaciation taking place at the two periods to which reference has been made, although the glaciation might not be severe.

In support of the opinion that there is no evidence of glaciation during the Tertiary period, Mr. Wallace quotes the views of Mr. Searles V. Wood, Jr., on the subject. Mr. Wood

states that the Eocene formation is complete in England, and is exposed in continuous section along the north coast of the Isle of Wight and along the northern coast of Kent from its base to the Lower Bagshot Sand. It has, he says, been intersected by cuttings in all directions and at all horizons, but has not yielded a trace of any thing indicating a cold and glacial condition of things. The same, he adds, holds true of the strata in France and Belgium. Further, "the Oligocene of Northern Germany and Belgium, and the Miocene of those countries and of France, have also afforded a rich molluscan fauna, which, like that of the Eocene, has as yet presented no indication of the intrusion of any thing to interfere with its uniformly subtropical character."

In reply to all this it may be stated that the simple absence of any trace of glaciation in the Tertiary deposits of the South of England certainly cannot be regarded as conclusive against the existence of an epoch of glaciation during that period. Not many years ago geologists denied that there was any evidence to be found of glaciation in the South of England, and at the present time there are hundreds of geologists who will not admit that that part was ever overridden by land-ice. If it is so difficult to find in that quarter evidence of the last glacial epoch, severe as that glacial epoch was, we need not wonder that no trace of glaciation so remote as that of the Eocene period is now to be seen. Besides all this, there is in the South of England the land-surface on which the glaciation, if any, took place, whereas not a vestige of the old land-surfaces of the Eocene period now remains. It therefore seems to me that the mere fact of nothing as yet having been found in the Tertiary deposits of the South of England, indicating one or more cold periods, is no proof that there may not possibly have been such periods, and even of considerable severity. The same remarks hold equally true in regard to the deposits on the continent referred to by Mr. Wood.

It will be urged in reply that there is one kind of evidence which ought to be found, as it could not possibly have been obliterated by the destruction of the Tertiary land-surfaces. That is the presence of erratic blocks and foreign rock-fragments imbedded in the strata. Mr. Wallace states that in the many thousand feet in thickness of alternate clays, sands, marls, shales, and limestones no irregular blocks of foreign material or bowlders characteristic of glacial conditions are to be found. The same, he says, holds equally true of the extensive Tertiary deposits of temperate North America.

If it be really the case that the Tertiary beds are wholly without bowlders or fragments of foreign material, then this

certainly may be regarded as proof that no real glacial epoch could have occurred during that period. But has it been satisfactorily ascertained that those beds are wholly devoid of such materials? Those beds, I presume, have been searched by geologists for their fossil contents rather than for stratigraphical evidence of glacial epochs. It is remarkable how long the evidence of glaciation sometimes remains unobserved when no special attention is devoted to the matter. As examples of this we know with certainty that the Orkney and Shetland Islands were during the Glacial epoch overridden by land-ice; and yet geologists who had often visited these islands declared that they bore no marks of glaciation. So recently as 1875 the low grounds of Northern Germany were believed to be without glacial striæ; yet when German geologists began to turn their attention specially to the subject, they found not only evidence of glaciation, but indisputable proof that during the Glacial epoch the great Scandinavian ice-sheet had advanced over the country no fewer than three separate times down to the latitude of Berlin. I have myself seen the striated summit of a mountain on which geologists had been treading for years without observing the ice-markings under their feet. The reasons why these markings so long escaped detection is doubtless due to the fact that they were on a spot which no geologist supposed that land-ice could have reached. For this very same reason the fact remained so long unobserved, that the low-lying ground of Caithness had been glaciated by land-ice from Scandinavia, filling the entire Baltic and the North Sea. Many similar cases might be adduced where the marks of glaciation remained long unobserved, either because no special search had been made for them or because they were under conditions in which they were not expected to be found. It is very probable that when the Tertiary deposits are carefully examined, with the special object of ascertaining whether or not they contain evidence of glaciation, geologists may be led to a different conclusion regarding the supposed uniformly warm character of the climate of that period. They may possibly find that, after all, the Tertiary beds do contain bowlders and foreign material, indicating the existence of glacial conditions during that period.

Considerable importance has been attached to the statement of Professor Nordenskjöld that he failed to observe in the stratified deposits of Greenland and Spitzbergen any evidence whatever of former glaciation in those regions. "We have never seen," says he, "in Spitzbergen nor in Greenland, in these sections often many miles in length, and including one may say all formations from the Silurian to the Tertiary, any bowlders even as large as a child's head. There is not the smallest

probability that strata of any considerable extent, containing bowlders, are to be found in the polar tracts previous to the middle of the Tertiary period. Both an examination of the geognostic condition, and an investigation of the fossil flora and fauna of the polar lands, show no signs of a glacial era having existed in those parts before the termination of the Miocene period."* That Prof. Nordenskjöld may not have seen in those strata bowlders larger than a child's head may be perfectly true, but that there actually are none is a thing utterly incredible. Still more incredible, however, is the conclusion which he draws from this absence of bowlders, viz: that from the Silurian down to the termination of the Miocene period no glacial condition of things existed either in Greenland or in Spitzbergen. Both these places are at present in a state of glaciation, and were it not, as we have seen, for the enormous quantity of heat which is being transferred from the equatorial regions by the Gulf-stream, not only Greenland and Spitzbergen, but the whole of the Arctic regions would be far more under ice than they are. A glacial state of things is the normal condition of polar regions, and if at any time, as during the Tertiary age, the Arctic regions were free from snow and ice, it could only be in consequence of some peculiar distribution of land and water and other exceptional conditions. That this peculiar combination of circumstances should have existed during the whole of that immense lapse of time between the Silurian and the close of the Tertiary period is certainly improbable in the highest degree. In short, that Greenland during the whole of that time should have been free from snow and ice is as improbable, although perhaps not so physically impossible, as that the interior of that continent should at the present day be free from ice and covered with luxuriant vegetation. Perhaps the same skill and indomitable perseverance which proved the one conclusion to be erroneous may yet one day prove the other to be also equally erroneous.

Professor Nordenskjöld does not appear to believe in alternations of climate even in temperate regions, for he says "from palæontological science no support can be obtained for the assumption of a periodical alternation of warm and cold climates on the surface of the earth."

Evidence of Glaciation during the Tertiary period.—Evidence of glaciation during the Miocene period is, I think, afforded by the well-known conglomerates and erratics near Turin, first described by M. Gastaldi. Beds of Miocene sandstone and conglomerate, with an intercalated deposit containing large angular blocks of greenstone and limestone, have been found. Some of these blocks are of immense size. Many of the stones in

* Geological Magazine, 1875, p. 531.

the deposit are polished and striated in a manner similar to those found in the Bowlder-clay of this country. It has been shown by Gastaldi that these blocks have all been derived from the outer ridge of the Alps on the Italian side, namely from the range extending from Ivrea to the Lago Maggiore, and, consequently, they must have traveled from twenty to eighty miles. So abundant are these large blocks that extensive quarries have been opened in the hills for the sake of procuring them. The stratification of the beds amongst which the blocks occur sufficiently indicate aqueous action and the former presence of the sea. That glaciers from the southern Alps actually reached to the sea, and sent adrift their icebergs over what are now the sunny plains of Northern Italy, is proof that during that cold period the climate must have been very severe. One remarkable circumstance, indicating not only the glacial condition of the bed in which the blocks occur, but also that this glaciation was the result of eccentricity, is the fact that the bed is wholly destitute of organic remains while they are found abundantly both in the underlying and overlying beds.

Evidence of glaciation during the Eocene period, as is also well known, is found in the "*flysch*" of Switzerland. On the north side of the Alps, from Switzerland to Vienna, and also near Genoa, there is a sandstone a few thousand feet in thickness, containing enormous blocks of Oolitic limestone and granite. Many of these blocks are upwards of 10 feet in length, and one at Haelkeren, near the Lake of Thun, is 105 feet long, 90 feet broad, and 45 feet in thickness. The block is of a granite of a peculiar kind which cannot be matched anywhere in the Alps. Similar blocks are found in beds of the same age in the Appenines and in the Carpathians. The glacial origin of this deposit is further evinced by the fact that it is wholly destitute of organic remains. One circumstance, which indicates that this glaciation was due to eccentricity, is the fact that the strata most nearly associated with the "*flysch*" are rich in Echinoderms of the *Spatangus* family, which have a decided tropical aspect. This is what we ought, of course, *à priori*, to expect if the glaciation was the result of eccentricity, for the more severe a cold period of a glacial epoch is, the warmer will be the periods which immediately precede and succeed.

Some writers endeavor to account for those glacial phenomena, without any reference to the influence of high eccentricity, by the assumption that the Alps were much more elevated during the Tertiary period than they are at the present day. If we, however, adopt this explanation, we shall have to assume that the Alps were suddenly elevated at the time when the bed containing the erratics began to be

deposited, and that they were as suddenly lowered when the disposition of the bed came to a close—a conclusion certainly very improbable. Had the lowering of the Alps been effected by the slow processes of denudation, it must have taken a long course of ages to have lowered them to the extent of bringing the glacial state to a close. In this case there ought to be a succession of beds indicating the long continuance of cold conditions. Instead of this, however, we have a glacial bed immediately preceded and succeeded by beds indicating an almost tropical condition of climate. When we take this circumstance into consideration, along with the evidence adduced by Mr. J. S. Gardner as to the alternations of warmer and colder conditions in the South of England and other parts of Europe during the Eocene period, the conviction is forced upon us that a high state of eccentricity is the most rational explanation of these curious phenomena.

The greater elevation of the Alps would undoubtedly intensify the glacial condition of things, but it would not originate it. The elevated character of the Alps, for example, was no doubt the reason why the plains of Switzerland, during the last glacial epoch, were so much more buried under ice than other parts of Southern Europe; but their elevation was not that which brought about the glaciation, for those plains were free from ice both before and after the glacial epoch, though the Alps were no doubt as high as they were during the ice-period.

If we adopt the theory that these glacial conditions were due to eccentricity, then we have, as I endeavored to show many years ago,* a clue to the probable absolute date of the Middle-Eocene and the Upper-Miocene periods. There were, as we have seen, two epochs during the Tertiary period when the eccentricity was exceptionally high, viz: 2,500,000 years ago and 850,000, years ago. The former might probably be the date of the "*flysch*" of the Eocene formation, and the latter the date of the period when the Miocene erratics were deposited in the icy sea near Turin.

Some geologists have maintained that the climatic conditions of the Tertiary period are utterly hostile to the Physical Theory of Secular changes of Climate. The very reverse, however, is the case; for, as we have seen, several of the facts of Tertiary climate can be explained on no other principle than that of the theory.

I shall next consider the facts bearing on Arctic Interglacial periods.

* Phil. Mag., November, 1868; 'Climate and Time,' chap. xxi.

ART. XXII.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No.* 11; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. LVII.

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Work of the Steamer Albatross in 1884.

THE deep-sea Anthozoa obtained last season were numerous and interesting, but there were among them only a few entirely new forms, for most of them had been dredged by the Albatross in 1883, or by the Blake in 1880. The most remarkable new species, of which one imperfect specimen had been taken in 1883, but not described, represents a new genus of Pennatulidæ. I have named this *Benthoptillum sertum.** This, which was taken in 991 to 1073 fathoms, is a remarkable exception

* *Benthoptillum*, gen. nov. Large, rather stout, Pennatula-shaped sea-pens, with very long and large polyps, arranged in several large, oblique, lateral clusters, arising from short, swollen, wing-like elevations, consisting of the united bases of the polyps and not supported by spines and spicules. The polyps throughout the greater part of their length are free, without calicles, and destitute of spicules. The tentacles are very long and plumose, without spicules. The zöoids are minute, very abundant, covering the ventral, lateral and dorsal surfaces of the rachis, and extending in rows on the bases of the polyps, leaving only a narrow, naked, median, ventral band. The axis extends through the whole length and is quadrangular, with concave sides. The stalk is rather short, with a terminal bulb and a slight enlargement near the upper end. The eggs are contained in the bases of the polyps within the lateral pinnæ.

Benthoptillum sertum, sp. nov. The pinnæ in the largest specimen are eight on each side and stand nearly opposite; those along the middle of the rachis largest, the others diminishing very gradually towards the stalk, the lowest pair being but slightly developed, very little prominent, consisting of only a few polyps which are united only very close to the base. The four middle pairs of pinnæ are very broad and swollen at the base, considerably elevated, and give rise to a very large number of long and large flexible polyps, which are arranged in numerous crowded rows, so as to form a large, compact cluster, the larger clusters having about forty polyps. The opposite clusters approach so closely on the dorsal side as to blend more or less together. The outermost row on the ventral side contains about twelve polyps the bases of which are swollen and distinguishable nearly to the base of the pinnæ. They form an oblique row in which the lower successively overlaps the one above it. The zöoids appear as minute granules, which cover the entire surface of the rachis, except the narrow, median, ventral band, and form groups between the bases of the polyps on the dorsal side, running up between their bases on the ventral side. The successive pairs of pinnæ are separated by considerable intervals on the ventral side, but nearly run together on the dorsal side. The axis is rather stout and has a deep groove on the ventral side.

In life the general color was blood-red. In alcohol the stalk and rachis are yellowish white with a tinge of orange on the sides; the polyps are translucent grayish white or dull purplish with the tentacles chestnut-brown to deep reddish brown, the stomach dull purplish color, showing through the walls.

Total length of the larger specimen, 300^{mm}; length of the naked stalk, 93^{mm}; diameter of the stalk, 5^{mm}; diameter of rachis, 6^{mm}; total breadth from tip to tip of expanded polyps, 140^{mm}; breadth across largest pinnæ, 22^{mm}; length of

to the generalization made by Professor Kölliker, in his report on the Challenger Pennatulacea, p. 38, that only the simpler forms of Pennatulacea occur in deep water, for our new genus is a very highly organized and specialized form, of large size, with complex lateral groups of very large polyps. But our two species of *Pennatula* (*P. aculeata* and *P. borealis*) both range downward to 1255 fathoms, and the generalization referred to will probably be found to rest on very insufficient evidence. A small species of *Stylatula* was also dredged in 444 fathoms, but it has not yet been identified. The genus was new to our Atlantic coast.

Three specimens of a very handsome European cup-coral (*Desmophyllum crista-galli*), never before observed on the American coast, were taken this year in 1054 to 1060 fathoms. Two of these were of very large size. Curiously enough another species of this genus was obtained at about the same time by one of the Gloucester fishing vessels off Nova Scotia and was sent to the Fish Commission at Wood's Holl by Capt. J. W. Collins. This is a very large and handsome species (*D. nobile* V.),* evidently entirely new. It somewhat resembles

free portion of polyps to tip of tentacles, 58mm; length of tentacles, 15mm; diameter of polyps at stomach, 3mm.

Station 2205, in 1073 fathoms, N. lat. 39° 35′, W. long. 71° 18′ 45″, one large specimen, and station 2210, in 991 fathoms, N. lat.? 39° 37′ 45″, W. long.? 71° 18′ 45″; station 2115, in 843 fathoms (No. 6729), 1883.

* *Desmophyllum nobile* V., sp. nov. Corallum solid, vase-shaped, arising from a broadly expanded base, a short distance above it contracts somewhat, and then expands to the summit. The walls are pure white, smooth, polished, somewhat lustrous, without any appearance of granulation. The calicle is broad, deep, nearly circular, and apparently thick at the edges, owing to the peculiar lateral thickening of the smallest septa. There is no visible columella. The septa are forty-eight, in four regular cycles. The twelve primary septa are very much higher and broader than the others, with the inner edges nearly perpendicular and converging so near the center as to leave but a very narrow central pit. Toward the summit the inner edge is obliquely truncated or slightly concave, while the extreme summit is broadly rounded and very prominent. The exterior margin is broadly rounded, usually flexuous or irregularly lobed or notched, and projects far beyond the border of the calicle in the form of very prominent, crest-like costæ, which extend a short distance below the margin of the calicle and then are suddenly narrowed, fading out entirely before reaching the narrowest part of the pedicle; they are rather thin at the inner and superior edges but are considerably thickened toward the wall and in their exterior portions; their surfaces within the calicle are coarsely granulated, but on their upper and outer portions the surfaces are glazed and polished. The secondary septa are similar in form and structure to the primary ones, but are much smaller and thinner, their inner edges do not extend so far inward and the summit does not rise nearly so high, but the exterior or costal portion is nearly as prominent and thick as the primaries, but is more suddenly narrowed and does not extend so far down the side of the coral. The septa of the third cycle are still narrower and lower, with the inner portions quite thin, while the portion next the margin of the calicle is very conspicuously thickened by swollen deposits which connect them laterally with the adjacent septa; their exterior portion is scarcely prominent, not forming distinct costæ.

Total height to the summit of the highest septa, 56mm; height to margin of

D. ingens Moseley, from the Straits of Magellan, but has only forty-eight septa, which are remarkably thickened and very unequal, while the exterior is smooth with an ivory-like polish. An apparently undescribed species of *Paracyathus* occurred in 1054 fathoms, but it has not been fully studied.

A peculiar new species of *Epizoanthus* (*E. abyssorum* V.) was taken several times in 1555 to 2033 fathoms. It usually formed the covering of a hermit-crab (*Parapagurus pilosimanus*). The polyps are rather large, usually five or six, divergent, clavate in contraction, and closely covered with a grayish coating of small foraminifera. The closed summit has twenty-four convergent radii. The polyps in alcohol are 10 to 15^{mm} long, 9 to 11^{mm} broad.

In addition to the starfishes referred to in my last article, there is, from 1098 and 1451 fathoms, a very interesting new species belonging to the peculiar deep-sea genus, *Hymenaster*,* of which many species were dredged by the Challenger in various parts of the world. An additional new species of *Archaster*† has also been recognized. It was taken in 858 fathoms, in 1883, and in 368 fathoms, in 1881.

calicle, 42^{mm}; diameter of the pedicle in the middle where narrowest, 21^{mm}; longest diameter of the calicle, 34^{mm}; shorter diameter, 31^{mm}; breadth of the primary septa, 20^{mm}; height above margin of calicle, 14^{mm}; breadth of the exterior or costal portion, 7^{mm}; breadth of secondary septa, 16^{mm}; height above margin of calicle, 8^{mm}; breadth of tertiary septa, 6^{mm}; height above margin of calicle, 4 to 5^{mm}.

The only specimen known was taken July 15th, 1884, on the "Stone Fence," on Banquereau, N. S., in about 300 fathoms (approximate position N. lat. 44° 28′, W. long. 57° 13′) by Michael Campbell, of Gloucester, Mass.

* *Hymenaster modestus*, sp. nov. Body small, pentagonal, with concave borders, rays short, broad, each adambulacral plate bears three very slender, acute spines; two are at the inner edge, and of these the distal is much shorter than the other; the third is external to the others, more erect and slightly larger. The ventral radial spines are very slender, not crowded, 16 to 18 on each side; the longest ones are the 5th and 6th; these and those beyond reach the margin, which is scolloped between them. The dorsal paxillæ project through the membrane as small spinules; they are pretty uniformly distributed and there are no defined radial areas. Color pale buff above, pink beneath. Greater radius, 10^{mm}; lesser radius, 7^{mm}. Stations 2052 and 2096, 1098 and 1451 fathoms.

† *Archaster sepitus*, sp. nov. This species is more nearly related to *A. tenuispinus* than to any of our other species. It agrees with the latter in form, in having a prominent, acute central spine on the dorsal paxillæ, and in the general character of the spinulation, in the projecting adambulacral plates, and apparently in the presence of special pores at the base of the arms. Its disk is smaller, its marginal plates more prominent and convex or swollen, its marginal spines much larger and more regular, and the spinules on the marginal plates much longer and sharper, while the ventral interbrachial areas are much smaller.

The marginal spines are longer than the breadth of the plates, and the spinules on the plates divergent and sharp. The lower plates are as prominent as the upper and bear similar spinules, with a median spine near the upper end, like those of the upper row, and sometimes with a lower one of the same form; these plates abut directly against the adambulacral plates. The latter project strongly into the groove and each bears a group of eight to ten slender divergent spines, those in the middle longest, with a larger, outer, erect central spine. Ventral interbrachial

Another large and handsome new star-fish, which was taken in several localities, in 843 to 1395 fathoms, both this year and last, is a species of *Solaster* (*S. abyssicola* V.)* somewhat resembling *S. endeca* and *S. Earllii* in general appearance, but differing from both in the arrangement of the spines, especially beneath. The color is bright orange in life. It becomes over a foot in diameter, with a broad disk, and usually eight or nine rays.

Among the deep sea Ophiurans no genus is more common and widely diffused than *Ophiacantha*. Of this genus we have taken, during the two past seasons, eleven or twelve species, besides one each of the closely allied genera *Ophiolebes* and *Ophiomitra*. Most of these forms live clinging closely to the branches of gorgonians. All the species that I have tested are brilliantly phosphorescent.

The most abundant are *O. bidentata*, *O. millespina* V. and *O. abyssicola* G. O. Sars; these three, which are very similar in appearance, are closely allied forms, and the last two may even prove to be identical. But some of the others, like *O. anomala*, with six arms, and *O. spectabilis*, with short, stout, granulose arm-spines and slender, tapering, acute disk spines, are very distinct forms. The same is true of three new species: *O. crassidens*,† having strong, acute disk-spines and remarkably

plates few, each with a sharp central spine, surrounded by an irregular group of small spinules. Greater radius, 34mm; lesser, 9mm; breadth of rays at base, 9mm. This example has 16 marginal plates in each row. Station 2072, in 858 fathoms, four specimens; station 994, in 368 fathoms, one young.

* *Solaster abyssicola* V., sp. nov. Disk broad. Rays usually eight or nine, varying to seven and ten. Abactinal side covered with rather small, not very close, rounded paxillæ, bearing small and short spinules. The branchial papulæ are large and numerous, thickly scattered on the disk and base of arms. Marginal plates prominent, bearing a transverse group of small, rough spinules, in two or three rows. Inter-brachial ventral areas of moderate size, covered with rounded paxillæ, similar to those of the back, arranged in regular rows, and bearing a divergent group of five to eight small, rough spinules. The adambulacral plates bear an outer transverse row of five to seven rather short, moderately thick spines, united at base and covered by a thick skin; and an inner group of three or four, nearly equal and rather short spines, united together by a web for about half their length.

† *Ophiacantha crassidens*, sp. nov. Arms five, rather short. Disk rounded, covered with rather small, tapered, subacute, slightly roughened spines, which arise from well developed, crowded plates, only partly concealed by a thin skin; radial shields nearly concealed. Arm-spines at base of arms, seven, hollow, minutely roughened or granulose, short, brownish, opaque, the five lower ones subequal, unusually short and blunt, becoming very short and acute distally; the next two rather longer and tapered; the uppermost smaller and more slender, acute, those of opposite sides well separated. Ventral arm-plates prominent, especially distally, the outer end rounded. Tentacle-scale large, stout, ovate, distally becoming short and blunt. Ventral side of disk distinctly scaled, with few spines. Mouth-shields triangular with acute inner angle, concave sides and convex outer margin, granulous. Teeth remarkably large, broad and thick, longitudinally roughened; mouth-papillæ few, three or four on each side, very stout, flattened, roughened and brown, like the teeth, which the

thick, stout teeth and mouth-papillæ; *O. enopla*,* with numerous long and very slender arm-spines, short obtuse stumps on the disk, and an unusually large number of slender acute mouth-papillæ, much crowded at the outer corners; and *O. granulifera*,† which has the disk closely covered with small granules and has unusually wide and short ventral arm-plates. Another large species,‡ of which several were found clinging to the arms of *Brisinga spinulosa* V., also appears to be new.

The *Ophiolebes Acanellæ* V., referred to above, lives clinging to the branches of *Gorgonians*, dredged off Nova Scotia, and closely resembles some species of *Ophiacantha*, but has fewer and shorter spines and its disk is covered with short, rough, round-topped stumps or large granules. *Amphilepis Norvegica* was taken several times in 1395 to 1555 fathoms.

The *Ophiomitra* is a new species § of large size, allied to

inner ones resemble in size and form, the others successively smaller. Color dull brown, the spines and teeth darker.

Diameter of disk, 13mm; length of arms about 40mm; largest spines, 2·5mm. Stat. 2115, in 843 fathoms, N. lat. 35° 49′ 30″, W. long. 74° 34′ 45″, 1 specimen, No. 9370.

* *Ophiacantha enopla*, sp. nov. Disk rounded, rather smaller, arms five, rather long, side plates prominent, with long, slender, glassy, acute, minutely thorny spines, of which there are eight in the largest clusters near the base of the arms, the three upper ones decidedly longer and smoother than the five lower ones; the clusters do not approach very nearly on the dorsal side, at the base of the arms. Dorsal plates rhombic, longer than broad. The disk is thickly covered with small, short, stout, blunt stumps, looking like granules, and terminated by a group of 5 to 8 small, rough, irregular spinules; beneath they become rounded granules. Mouth-shields small, transversely elongated and subrhombic, the outer angle slight, scarcely extending on the interbrachial area. Tentacle-scale minute; mouth-papillæ rather long, acute, very numerous, 7 to 9 on each side of each jaw, crowdedly clustered near the outer end of the mouth-slits, where there are five or six standing nearly erect on each side, while two or three more horizontal ones stand nearer the inner end. Yellowish white in alcohol; orange while living.

Diameter of disk, 12mm; length of arms, 6½mm; longest spines, 4mm.

Stations 1122, 1124, 2046, in 351 to 640 fathoms.

† *O. granulifera* V., sp. nov. Disk finely granulated, with slightly raised radial ridges, showing the naked tips of the radial shields. Arms rather broad, arm-spines on basal joints, 8 or 9, a little rough; the upper ones long and slender, the rows not approximating above; tentacle-scale small, lanceolate, except the basal ones. Ventral plates short, transversely oblong on 2d to 7th joints, becoming trapezoidal farther out. Radial shield strongly 4-lobed, small. Mouth-papillæ all spiniform, 3 or 4 on each side of a jaw.

Diameter of disk 9 to 11mm. Off Nova Scotia, 101 to 200 fathoms.

‡ *Ophiacantha aculeata*, sp. nov. A large orange species with long tapering arms, and very long, slender, slightly rough spines, 8 or 9 on each side, near the disk, the rows nearly meeting above. The disk is rounded and full, with the ends of radial shields not exposed; surface evenly covered with very slender rough spinules, terminated by several sharp points. Jaws wider and more obtuse than usual; the mouth-papillæ are rather slender, all acute, usually 4 or 5 on each side of a jaw. Tentacle scale lanceolate acute, not very large. Mouth-shields rather small, convex on outer edge, obtusely angled on the inner.

Stations 2034 and 2105, in 1346 and 1395 fathoms.

§ *Ophiomitra spinea* V., sp. nov. Radial-shields broad-ovate, notched at outer end, separated by a triangular wedge of scales; small unequal scales cover the disk, and bear small conical and rounded granules. Arm-spines 8 or 9 at base of

List of Stations occupied by the Albatross in 1884.

Station.	Locality.		Fath.	Bottom.	Temp., F.		Hour.	Date.
					Bottom.	Surface.		
	Off Chesapeake Bay.							
	N. Lat.	W. Long.						July
2170	37° 57′ 00″	73° 53′ 30″	155	gy. s	--	71°	11.40 A. M.	20
2171	37 59 30	73 48 40	444	gn. m., s., cns.	39°	75	1.25 P. M.	20
2172	38 01 15	73 44 00	568	"	39	76	3.45 "	20
2173	37 57 00	72 34 00	1600	glb. o.	37	70	6.26 A. M.	21
2174	38 15 00	72 03 00	1594	gy. m.	?	76	2.59 P. M.	21
	Off Martha's Vineyard.							
2175	39 33 00	72 18 30	452	gn. m.	40	68	9.03 A. M.	22
2176	39 22 30	72 21 30	302	bk. m.	41	68	12.34 "	22
2177	39 33 40	72 08 45	87	gn. m., s.	42	68	3.40 P. M.	22
2178	39 29 00	72 05 15	229	"	42	68	5 16 "	22
2179	39 30 10	71 50 00	510	bk. m.	39	67	4.02 A. M.	23
2180	39 25 50	71 49 30	523	"	39	68	6.48 "	23
2181	39 29 00	71 46 00	693	m., fne. s.	39	68	9.42 "	23
2182	39 25 30	71 44 00	861	gn. m.	39	68	12.58 m.	23
								Aug.
2183	39 57 45	70 56 30	195	gn. m., s.	44	68	11.52 A. M.	2
2184	40 00 15	70 55 30	136	"	49	70	1.08 P. M.	2
2185	40 00 45	70 54 15	129	"	51	69	2.12 "	2
2186	39 52 15	70 55 30	353	"	40	69	6.12 "	2
2187	39 49 30	71 10 00	420	gn. m.	40	68	10.44 A. M.	3
2188	39 54 30	71 08 00	235	gn. m., s.	43	70	1.54 P. M.	3
2189	39 49 30	70 26 00	600	gn m.	40	71	4.16 A. M.	4
2190	39 40 00	70 20 15	1180	gn. glb. o.	--	73	10.42 "	4
2191	39 45 30	70 17 00	961	gn. m.	--	73	2.46 P. M.	4
2192	39 46 30	70 14 45	1060	o., c., cns.	39	72	5.45 A. M.	5
2193	39 44 30	70 10 30	1122	gn. m.	38	73	11.04 "	5
2194	39 43 45	70 07 00	1140	bn. o.	38	74	2.54 P. M.	5
2195	39 44 00	70 03 00	1058	gn. m., st.	38	74	6.42 "	5
2196	39 35 00	69 44 00	1230	"	38	74	4.45 A. M.	6
2197	39 56 30	69 43 20	84	s., brk. sh.	52	74	11.24 "	6
2198	39 56 30	69 43 20	84	"	52	74	1.17 P. M.	6
2199	39 57 30	69 41 10	78	gn. s.	--	74	2.03 "	6
2200	39 53 30	69 43 20	148	s., brk. sh.	45	74	4.38 "	6
2201	39 39 45	71 35 15	538	bu. m.	39	66	6.10 A. M.	19
2202	39 38 00	71 39 45	515	gn. m.	39	67	9.23 "	19
2203	?39 34 15	71 45 15	705	gn. m., s.	39	74	12.20 P. M.	19
2204	?39 30 30	71 44 30	728	bu. m.	39	74	4.32 "	19
2205	39 35 00	71 18 45	1073	gy. o.	38	73	4.37 A. M.	20
2206	?39 35 00	71 24 30	1043	gn. m.	38	74	9.16 "	20
2207	39 35 33	71 31 45	1061	"	39	74	1.01 P. M.	20
2208	39 33 00	71 16 15	1178	gn m. st., cns.	38	74	5.02 A. M.	21
2209	39 34 45	71 21 30	1080	glb. o.	39	74	9.42 "	21
2210	?39 37 45	71 18 45	991	"	38	74	1.18 P. M.	21
2211	?39 35 00	71 18 00	1064	gn. m.	38	74	4.45 "	21
2212	?39 59 30	70 30 45	428	"	40	71	4.48 A. M.	22
2213	?39 58 30	70 30 00	384	"	39	71	8.04 "	22
2214	39 57 00	70 32 00	475	"	39	74	11.30 "	22
2215	39 49 15	70 31 45	578	----	--	74	3.13 P. M.	22
2216	39 47 00	70 30 30	963	gn. m.	39	71	5.38 "	22
2217	39 47 20	69 34 15	924	gy. m.	38	73	4.49 A. M.	23
2218	39 46 22	69 29 00	948	"	39	74	10.41 "	23

List of Stations occupied by the Albatross in 1884—*continued.*

Station.	Locality.	Fath.	Bottom.	Temp., F.		Hour.	Date.
				Bottom.	Surface.		
	Off Martha's Vineyard.						Aug.
	N. Lat. W. Long.						
2219	39°46′22″ 69°29′00″	948	gy. m.	39°	74°	1.36 P. M.	23
2220	?39 43 30 69 23 00	1054	"	38	74	4.18 "	23
							Sept.
2221	39 05 30 70 44 30	1525	gy. o., bricks.	37	75	9.01 A. M.	6
2222	39 03 15 70 50 45	1537	"	37	73	2.20 P. M.	6
	Off Chesapeake Bay.						
2223	37 48 30 69 43 30	2516	glb. o.	36	75	5.07 A. M.	7
2224	36 16 30 68 21 00	2574	"	37	79	8.31 "	8
2225	36 05 30 69 51 45	2512	yl. o.	37	78	5.47 "	9
2226	37 00 00 71 54 00	2021	glb. o., st.	37	80	5.06 "	10
2227	36 55 23 71 55 00	2109	"	37	82	12.24 P. M.	10
2228	37 25 00 73 06 00	1582	bu. m., cns.	37	77	5.10 A. M.	11
2229	?37 38 40 73 16 30	1423	glb. o.	38	75	4.12 P. M.	11
	Off Delaware Bay.						
2230	38 27 00 73 02 00	1168	gy. o., c., cns.	37	75	4.37 A. M.	12
2231	38 29 00 73 09 00	965	"	37	75	9.42 "	12
2232	?38 37 30 73 11 00	243	gn. m.	43	74	2.48 P. M.	12
2233	?38 36 30 76 06 00	630	"	39	73	4.16 "	12
	Off Martha's Vineyard.						
2234	39 09 00 72 03 15	816	gn. m.	39	71	4.30 A. M.	13
2235	39 12 00 72 03 30	707	"	39	72	7.33 "	13
2236	39 11 00 72 08 30	636	"	39	72	9.49 "	13
2237	39 12 17 72 09 30	520	"	39	72	11.42 "	13
2238	39 06 00 72 10 00	904	gy m.	39	72	2.26 P. M.	13
2239	40 38 00 70 29 45	32	gn. m.	--	62	5.05 A. M.	26
2240	40 27 30 70 29 00	44	"	--	61	7.29 "	26
2241	40 21 00 70 29 15	50	"	51	63	9.20 "	26
2242	40 15 30 70 27 00	58	"	51	63	11.33 "	26
2243	40 10 15 70 26 00	63	"	52	64	1.13 P. M.	26
2244	40 05 15 70 23 00	67	gn. m., s.	53	71	3.11 "	26
2245	40 01 15 70 22 00	98	m., bk. s.	51	61	4.50 "	26
2246	39 56 45 70 20 30	122	gn. m.	48	71	6.43 "	26
2247	40 03 00 69 57 00	78	gn. m., s.	52	70	4.57 A. M.	27
2248	40 07 00 69 57 00	67	m., s., brk. sh.	52	70	6.50 "	27
2249	40 11 00 69 52 00	53	m., fne. s.	51	70	8.24 "	27
2250	40 17 15 69 51 45	47	"	51	68	10.04 "	27
2251	40 22 17 69 51 30	43	"	51	65	12.02 P. M.	27
2252	40 28 00 69 51 00	38	"	50	63	1.46 "	27
2253	40 34 30 69 50 45	32	s., bk. spk.	53	61	3.11 "	27
2254	40 40 30 69 50 30	25	"	54	61	4.39 "	27
2255	40 46 80 69 50 15	18	"	56	60	6.10 "	27
2256	40 38 30 69 29 00	30	yl. s.	53	61	5.42 A. M.	28
2257	40 32 30 69 29 00	33	s., bk. spk.	52	61	7.17 "	28
2258	40 26 00 69 29 00	36	"	51	61	8.34 "	28
2259	40 19 30 69 29 10	41	"	50	61	9.56 "	28
2260	40 13 15 69 29 15	46	gy. s.	50	65	11.13 "	28
2261	40 04 00 69 29 30	58	s., bk. spk.	54	66	12 52 P. M.	28
2262	39 54 45 69 29 45	250	gn. m., s.	42	67	2.51 "	28

List of Stations occupied by the Albatross in 1884—*continued.*

Station.	Locality.		Fath.	Bottom.	Temp., F.		Hour.		Date.
					Bottom.	Surface.			
	Off Chesapeake Bay.								Oct.
	N. Lat.	W. Long.							
2263	37°08′00″	74°33′00″	430	gn. M.	47°	66°	1.06	P. M.	18
2264	37 07 50	74 34 20	167	gy. S.	58	66	2.37	"	18
2265	37 07 40	74 35 40	70	gn. M., G., sh.	63	67	3.47	"	18
	Off Cape Hatteras.								
2266	35 07 00	75 08 30	111	fne. S.	73	78	6.00	A. M.	19
2267	35 08 50	75 07 20	68	gy. M.	71	79	6.39	"	19
2268	35 10 40	75 06 10	68	"	77	79	7.43	"	19
2269	35 12 30	75 05 00	48	crs. G.	76	75	8.46	"	19
2270	35 14 15	75 07 00	32	fne. gy. S.	--	75	9.40	"	19
2271	35 16 00	75 09 00	26	----	--	75	10.45	"	19
2272	35 20 10	75 14 00	15	S., bk. spk.	--	75	11.57	"	19
2273	35 20 30	75 17 30	17	"	72	72	12.45	P. M.	19
2274	35 20 35	75 18 05	16	"	--	71	1.22	"	19
2275	35 20 40	75 18 40	16	"	--	71	1.43	"	19
2276	35 20 45	75 19 15	16	"	--	71	2.08	"	19
2277	35 20 50	75 19 50	16	"	--	71	2.21	"	19
2278	35 20 55	75 20 20	16	"	--	71	2.45	"	19
2279	35 20 55	75 20 55	16	"	--	71	3.36	"	19
2280	35 21 00	75 21 30	16	"	--	70	4.15	"	19
2281	35 21 05	75 22 05	16	"	--	70	4.35	"	19
2282	35 21 10	75 22 40	14	bk. S.	--	70	5.13	"	19
2283	35 21 15	75 23 15	14	gy. S.	--	70	5.41	"	19
2284	35 21 20	75 23 50	13	crs. gy. S.	--	70	6.09	"	19
2285	35 21 25	75 24 25	13	"	--	70	6.40	"	19
2286	35 21 30	75 25 00	11	"	--	70	7.13	"	19
2287	35 22 30	75 26 00	7	"	--	69	6.15	A. M.	20
2288	35 22 40	75 25 30	7	S., brk., sh.	--	69	6.45	"	20
2289	35 22 50	75 25 00	7	"	--	69	7.15	"	20
2290	35 23 00	75 24 30	10	"	--	69	7.45	"	20
2291	35 25 30	75 20 30	15	"	--	69	8.45	"	20
2292	35 27 20	75 16 30	17	"	--	70	9.32	"	20
2293	35 29 10	75 12 30	18	crs. S.	--	71	10.25	"	20
2294	35 31 00	75 08 30	19	crs. gy. S.	--	71	11.18	"	20
2295	35 32 41	75 04 30	22	"	--	73	12.03	P. M.	20
2296	35 35 20	74 58 45	27	"	--	71	1.15	"	20
2297	35 38 00	74 53 00	49	M., brk., sh.	--	73	2.18	"	20
2298	35 39 00	74 52 00	80	"	--	73	2.55	"	20
2299	35 40 00	74 51 30	296	bk. M.	--	73	3.50	"	20
2300	35 41 30	74 48 30	671	"	--	71	5.20	"	20
2301	35 11 30	75 05 00	59	crs. S.	75	77	6.10	A. M.	21
2302	35 14 00	75 03 00	49	S., C.	71	77	6.45	"	21
2303	35 17 00	75 01 00	41	fne. S.	--	77	7.11	"	21
2304	35 19 00	74 58 00	37	"	--	77	7.40	"	21
2305	35 23 00	74 51 30	58	"	66	79	8.36	"	21
2306	35 21 30	74 52 00	322	gy. M.	42	79	11.00	"	21
2307	35 42 00	74 54 30	43	gy. & bk. S.	57	70	4.11	P. M.	21
2308	35 43 00	74 53 30	45	"	--	71	5.17	"	21
2309	35 43 30	74 52 00	56	S., bk. spk.	--	71	6.08	"	21
2310	35 44 00	74 51 00	132	bk. M., S.	--	71	6.59	"	21

O. valida, but having more numerous arm-spines and much smaller rounded and sharp granules on the disk. It was taken at station 2035, in 2038 fathoms.

A curious orange species of *Hemieuryale* (*H. tenuispina* V., formerly *Astronyx tenuispina* V.), always occurs on *Scleroptilum elegans* in 1362 to 1608 fathoms. The disk and arms are covered with thin, rounded scales, not easily seen until dried, and a row of projecting plates runs along each side of the arms above.

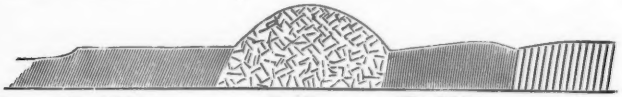
ART. XXIII.—*Note on a Fossil Coal Plant found at the Graphite deposit in Mica schist, at Worcester, Mass.;* by JOSEPH H. PERRY.

IN the eastern part of Worcester, there is a granite knoll rising about three hundred feet above the surrounding country, and surrounded on all sides by the formation referred to by Professor Edward Hitchcock as mica slate or mica schist. In this mica schist is contained the coal deposit of Worcester as to whose age there has been much doubt. Professor E. Hitchcock believed it to be much earlier than the coal formation at Mansfield and Wrentham; and Professor C. H. Hitchcock assigns the mica schist to the Huronian.

I have recently found at the coal mine two specimens of a fossil coal plant of the genus Lepidodendron, the largest about eighteen inches long and six wide. The whole of one surface of the specimen and the larger part of the other are covered with the narrow rhombic scars, which where most distinct are about an inch long. The specimen has been examined by Professor J. D. Dana, by whom photographs were sent to Professor Lesquereux. The latter referred the fossil to the very rare species "*Lepidodendron* (*Sagenaria*) *acuminatum* of Gœppert (Foss. Fl. d. Uebergangsgebirge, 1852, p. 185, pl. xxxiii), partly, especially fig. 4, which however does not give so good a representation of the plant as the figure in Heer's Culm Fl., p. 291, plate xxii, fig. 4;" and he adds: "the specimen (photograph) is the first I have seen from America; the specimens from which Goeppert made the species were from the Carboniferous limestone of Silesia." He also says: "It is very much like a variety of the old and most common *Lepidodendron Veltheimianum* Sternb.; but it shows a marked difference in the disposition of the scars (cicatrices) to be arranged in a verti-

arms, long and slender, somewhat thorny. Mouth-papillæ unequal, mostly slender, spiniform, crowded outwardly, about 6 to 9 on each side of a jaw. Mouth-shields 4-lobed, the inner end angulated. Tentacle-scale large, flat; inner ones obtuse, others lanceolate. Diameter of disk 14^{mm}.

cal direction, forming ribs like those of Sigillaria." These ribs are really long spiral, and Lesquereux, although he has observed the same in another species, queries whether they are normal or not. The Carboniferous limestone of Silesia corresponds (as I am informed by Professor Dana) to the American Subcarboniferous.



The section represented in the accompanying figure has in the center the granite knoll, and extends to the northwest only far enough to show the mica schist resting against the granite. To the southeast the section cuts through the mica schist into the gneiss which lies to the east and southeast toward Mansfield and Wrentham. The gneiss and mica schist are conformable, having a general strike northeast and southwest, and where the section was made a dip of 75° to 85° to the northwest inclined away from the granite.

The outcrop of the coal-bearing strata of the mica schist is about half a mile northeast from the top of the granite knoll. Here the strike is northwest by southeast at about right angles to the strike of the mica schist outcropping not more than an eighth of a mile distant to the east. The dip is about 50° to the northeast, the strata leaning toward the granite. The fact that the same rock, identified by peculiar markings as well as by constitution, varies so greatly in dip and strike within so short a distance, indicates an additional disturbance to that which tilted the whole mica schist and gneiss to their present position and transformed them to their present condition. This additional disturbance was the forcing up from beneath of the granite knoll, breaking or bending the strata to the northeast and north, away from that to the east. This thorough working over of the rocks containing the carboniferous deposit has transformed this deposit for the most part into graphite; and in the specimen, mentioned above, the carbon is in the form of graphite though the scars of the plant are distinctly preserved.

It is my purpose to follow the rocks to the southeast and then to the west during the next season. So far as I have gone, I find my results agreeing quite closely with those of Professor E. Hitchcock.

High School, Worcester, Mass.

ART. XXIV.—*The Test Well in the Carboniferous Formation at Brownville, Nebraska;* by Professor L. E. HICKS of the University of Nebraska.

IT has long been a mooted question, both in the minds of geologists and of practical miners, whether there is coal in Nebraska that will pay for mining. The citizens of Brownville, Nemaha county, have been making a practical test of this matter for which they deserve much credit, since their test well has brought to light facts of great scientific interest and value irrespective of the economical results.

The boring was begun at an elevation of 919 feet above the level of the sea, and carried to the depth of 1,000 feet 10 inches, or 81 feet 10 inches below sea level. The surface rocks at Brownville are Upper Carboniferous and show traces of coal, as, for instance, in the west bank of the Missouri river just above the railway station. The drill penetrated the Lower Coal Measures but did not pass through them. These are the productive measures of the Carboniferous in Iowa and in the States farther east. Here, therefore, is the place to find coal if it exists at all in paying quantities in Nebraska. The only seam found in the Lower Coal Measures was one of bituminous coal of fair quality, 30 inches in thickness, at a depth of 820 feet 8 inches. The boring was carried 180 feet farther without encountering any more coal. Below the thirty inch seam nothing was encountered but the shales, limestones and sandstones ordinarily found in the Lower Coal Measures. This renders it improbable that any more coal would be found at greater depths, although the demonstration would have been more complete if the hole had been put down one or two hundred feet deeper.

Above the thirty inch seam three other thin seams were found; one 8 inches thick at a depth of 93 feet, another 14 inches thick at a depth of 242 feet, and a third 10 inches thick at a depth of 375 feet. These evidently belong to the Upper Coal Measures, as there is an interval of nearly 400 feet of barren rocks between them and the thirty inch seam. Immediately below the 14 inch seam is a stratum of sandstone 20 feet thick containing water strongly impregnated with salt and other minerals in solution, which flowed out at the top of the well.

Whether the thirty inch seam can be profitably worked at a depth of 820 feet is a question for the practical miner rather than for the geologist. It would at once be answered in the negative where fuel is plenty, but in this land of prairies and

magnificent distances from productive mines the answer is not so much a matter of course.

I have a complete record of all the strata encountered, to the number of sixty-two, and will cheerfully furnish it upon application.

ART. XXV.—*Review of Hill's Supplement to Delaunay;* by JOHN N. STOCKWELL.

ASTRONOMERS in all parts of the world are always delighted on the appearance of any and all papers which are issued from the office of the American Ephemeris. A distinguishing characteristic of all these papers is the exhaustiveness with which the subjects deemed worthy of consideration are analyzed and discussed. Commencing in the year 1879, soon after the present eminent mathematician and astronomer, Professor Newcomb, became its Superintendent, a series of papers have been issued which embrace a wide variety of interesting astronomical subjects; and the ability which has been displayed in the preparation of these papers has gained for them a world-wide reputation. I was therefore unusually interested in the one which has recently appeared, entitled, "A Supplement to Delaunay's Lunar Theory, by G. W. Hill, Assistant American Ephemeris;" because it contained an investigation of a problem on which I had already bestowed much attention. From the vast extent to which the solution of the problem has been carried, it is evident that the eminent author was determined that the past reputation of these papers should suffer no detriment from this. The investigation covers 136 large quarto pages, and gives 165 inequalities in the longitude, 209 inequalities in the latitude and five inequalities in the radius vector, all of which are said to be correct to quantities of the seventh order. Of these 374 inequalities in the longitude and latitude, only seventeen exceed *one-twentieth* of a second of arc; and only two exceed *one* second. The vast development, however, shows the thoroughness with which the work was intended to be done, and if it is not what Mr. Hill claims for it in point of accuracy it is owing to some oversight rather than to deliberate neglect of any known cause of perturbation.

I do not purpose, however, to speak of the results of this solution which are common to all the solutions of this problem which I have seen, further than to say that it contains the same manifest absurdity in the principal equation of the latitude: namely, that it makes the coefficient of this inequality directly proportional to the cube of the sun's distance from the earth:

from which it follows that were the earth and moon to revolve around the sun in their present relations to each other, but at the distance of Neptune, the inequality would be more than 27,000 times greater than at present. This single fact ought to justify the suspicion that possibly the entire solution is erroneous. This result cannot be regarded as an oversight, but rather as a faulty solution, the origin of which it is easy to explain.

But I find on careful examination that there has indeed been a remarkable oversight committed in the developments of this work, and that not more than *two* of the inequalities, if indeed *any* of them are deserving of any confidence in point of accuracy; nor can these two be correct to terms of a higher order than the third or fourth.

In order to give a general explanation of the oversight which seems to have been committed in this work, I would observe that Mr. Hill has first determined the disturbing force which is due to the earth's figure on the supposition that the moon's motions are not affected by the sun's attraction. The real disturbing force of the earth is, however, a function not only of the earth's figure, but also of the moon's coördinates, and since the moon's coördinates are affected by the sun's attraction, it follows that there must be a modification of the earth's force arising from that cause. This effect of the sun Mr. Hill has correctly allowed for, and it would therefore *seem* at first view, that if he has allowed for the earth's force and also for its modification by the sun's action, that the whole effect of the earth's figure on the moon's motion would be accurately determined by his investigation. But in reality the sun's disturbing force is modified by the earth's figure to terms of the same order as those by which the earth's force is modified by the sun's attraction. It is therefore necessary to consider these terms if we propose to carry the approximations to terms of the order of the products of the disturbing masses. But these terms Mr. Hill has entirely omitted; and hence it follows that all the terms of the order of the products of the disturbing masses in his investigation must necessarily be erroneous, no matter to what extent the development in terms of the eccentricity and inclination may be carried.

It may, however, be more satisfactory to mathematicians to have the preceding statements translated into symbolic language. For this purpose let us put R_0 and R_1 for the disturbing functions due to the earth and sun respectively, and also put R for the total disturbing function, we shall have

$$R = R_0 + R_1 \qquad (1)$$

But since R is a function of the moon's coördinates r, v and

θ, we shall have the whole variation of R due to any variations in the coördinates by means of the equation

$$\left.\begin{aligned}\delta R&=\left(\frac{dR}{dr}\right)\delta r+\left(\frac{dR}{dv}\right)\delta v+\left(\frac{dR}{d\theta}\right)\delta\theta\\&=\left(\frac{dR_0}{dr}\right)\delta r+\left(\frac{dR_0}{dv}\right)\delta v+\left(\frac{dR_0}{d\theta}\right)\delta\theta+\left(\frac{dR_1}{dr}\right)\delta r+\left(\frac{dR_1}{dv}\right)\delta v\\&\qquad+\left(\frac{dR_1}{d\theta}\right)\delta\theta\end{aligned}\right\}\quad(2)$$

Now δr, δv and $\delta\theta$ denote the total perturbations of the coördinates; they must therefore be the sums of the perturbations arising from the action of the earth and sun. Putting therefore $\delta_0 r$, $\delta_1 r$, $\delta_0 v$, $\delta_1 v$, $\delta_0\theta$, $\delta_1\theta$ for the variations arising from the action of the earth and sun respectively, we shall have

$$\delta r=\delta_0 r+\delta_1 r\quad \delta v=\delta_0 v+\delta_1 v\quad \delta\theta=\delta_0\theta+\delta_1\theta\qquad(3)$$

If we substitute these values of δr, δv and $\delta\theta$ in equation (2), and retain only the terms depending on the products of the masses, we shall find,

$$\left.\begin{aligned}\delta R&=\left(\frac{dR_0}{dr}\right)\delta_1 r+\left(\frac{dR_0}{dv}\right)\delta_1 v+\left(\frac{dR_0}{d\theta}\right)\delta_1\theta\\&\quad+\left(\frac{dR_1}{dr}\right)\delta_0 r+\left(\frac{dR_1}{dv}\right)\delta_0 v+\left(\frac{dR_1}{d\theta}\right)\delta_0\theta\end{aligned}\right\}\qquad(4)$$

Now Mr. Hill has taken account of only the first three terms of this equation and has omitted all consideration of the last three. But if Mr. Hill's values of $\delta_0 r$, $\delta_0 v$, $\delta_0\theta$ are correct, these last three terms are of much more importance than the first three. Indeed it is one of the curiosities or rather paradoxes of the whole theory, that, if Mr. Hill's value of $\delta_0 r$, $\delta_0 v$, $\delta_0\theta$ be substituted in the last equation the value of δR will be equal to $-R_0$, and the whole disturbing function arising from the earth's figure will vanish; at least as far as the terms depending on the coefficient β_2 of Mr. Hill's work are concerned, and hence all the inequalities depending on that coefficient ought to vanish also. But if the values of $\delta_0 r$, $\delta_0 v$ and $\delta_0\theta$ which I have determined, are substituted in the last three terms of equation (4) we get rational and consistent values, of the same order of magnitude as Mr. Hill has derived from the first three terms. This is a strong corroboration of the statement which I made at the Philadelphia meeting of the American Association in September, namely, that the computed values of the lunar inequalities arising from the earth's figure are erroneous.

This fundamental defect in the theory, to which I have called attention, renders it entirely valueless as a scientific

deduction, so that a more detailed analysis of the work is unnecessary in this place; but there is one point of especial interest to which I would like to call attention, and that is the secular equation of the longitude which depends on the obliquity of the ecliptic. By referring the equator and the moon's coördinates to a fixed plane instead of to the variable ecliptic, Mr. Hill has seemingly obtained a solution which is free from secular terms, but, if we remember that in this case the inclination of the orbit becomes variable to the same extent as the obliquity of the ecliptic in my solution, we shall obtain precisely the same secular equation. La Place, nearly a hundred years ago, called attention to the fact that the secular motion of the ecliptic produced a secular change in the moon's declination, and since this declination is the principal variable quantity in the expression of the earth's disturbing force, it seems strange that Mr. Hill should have entirely overlooked one of its most obvious consequences.

Although the defect to which I have called attention renders the work of no value as a scientific deduction, it is nevertheless really valuable on account of the elegance and symmetry which pervades its vast expansion; and it may be examined with great advantage by the matured mathematician as well as by the younger student of celestial mechanics.

Cleveland, Nov. 8, 1884.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Relation between the Velocity of Evaporation of Liquids and their Molecular weights.*—Schall has continued his researches upon the connection between the time of evaporation of liquids and their molecular weights.* In place of measuring the increase in the vapor volume, he has now measured the time required for the liquid to diminish by a given amount. The apparatus (a figure of which is given) consists of a bent tube carefully calibrated, to hold the liquid, enclosed in a flask containing a suitable vapor in contact with its liquid as a source of heat. The progress of the evaporation was observed with a cathetometer. In order to determine the density of the liquids used, at their boiling points, a specific gravity flask filled with the liquid was placed in a cylinder containing the same liquid in ebullition. When the liquid had reached the required temperature, the sp. gr. flask was closed with a tight-fitting stopper,

* This Journal, III, xxvii, 233, March, 1884.

cooled and weighed. Taking the liquids in pairs, the molecular weight of either one is calculable by the formula $m = \frac{m'Dt'}{D't}$, in which m, D and t represent the molecular weight, the density at the boiling point and the time of evaporation respectively. Thus for aniline $D = 0{\cdot}8731$ and for phenol $D' = 0{\cdot}9208$. In two experiments t for the former was 3·8 minutes and t' for the latter 3·9 minutes. Since the molecular weight of phenol is 94, the molecular weight of aniline $= \frac{94 \times 0{\cdot}8731 \times 3{\cdot}9}{0{\cdot}9208 \times 3{\cdot}8} = 91{\cdot}48$. Two other experiments gave 91·91, the calculated value being 93. So, calculating the molecular weight of phenol, the values 95·57, 95·11, 95·11 were obtained; the calculated molecular weight being 94. Benzoyl chloride (140·5) and ethyl benzoate (150) gave for the former the values 144·3 and 144·5; and for the latter 145·7 and 145·2. Twenty-four similar pairs of liquids were examined with correspondingly close results. The following are the conclusions of the paper: 1st, when liquids are evaporated in their own vapors, the times of evaporation of equal weights are inversely proportional to their molecular weights. 2d, the latent heats of evaporation are proportional to the times of evaporation of equal weights of the liquids. 3d, at the boiling point, liquid acetic acid has the molecular weight 89·8 and formic acid, 69.—*Ber. Berl. Chem. Ges.*, xvii, 2199, October, 1884. G. F. B.

2. *On the Quantitative determination of Metals by Electrolysis.*—In a third paper on this subject, CLASSEN gives the results of his experiments on the quantitative electrolysis of metallic solutions by means of the magneto-electric current. For this purpose he uses a small Siemens dynamo, driven from a counter-shaft as usual. This counter-shaft however has a cone pulley and is driven from another counter-shaft having upon it a similar cone pulley and also a fast and loose pulley, over which runs the belt from the main shaft. By this arrangement the speed of the dynamo may be varied at pleasure from 100 to 700 revolutions per minute. By means of a resistance box, placed in the main circuit, the coils of which vary from 0·01 to 3 ohms the current-strength may also be varied. So that by both these arrangements the author has command of a current varying at will from 0·02 to 7·46 ampères. On a vertical rod connected with the negative electrode is a ring for supporting the platinum dish containing the solution. An arm sliding on the same rod, but insulated from it, supports the positive electrode. The platinum dish used weighs from 35 to 37 grams, is 9 cm. in diameter and 4·2 cm. deep and holds about 225 c.c. water. Care is required to have it perfectly smooth and clean. For the determination of copper and of cadmium the double ammonium oxalate solution is preferred. The current used should be about 0·02 ampère, such as would be obtained by joining two Bunsen cells in parallel circuit. The separation is complete in from ten to twelve hours for about 0·15 grm. copper, the end reaction being

determined by ferrocyanide. For 0·1425 grm. of copper used in six experiments the process gave 0·1425 grm. in four and 0·1420 in two. In the case of cadmium, 0·1235, 0·1480, 0·2385 grms. were used and 0·12325, 0·1470 and 0·2380 recovered. For the separation of iron and copper, solutions of iron alum and copper sulphate were mixed with ammonium oxalate in excess, and electrolyzed. After the copper was separated, more ammonium oxalate was dissolved in the solution and the iron thrown down electrolytically. Copper was separated from cobalt and nickel in the same way; as also from chromium, magnesium, aluminum, manganese and zinc. In the latter case the solution is made acid with sulphuric acid. For the precipitation of antimony, its solution in sodium monosulphide free from polysulphide is used. Tin gives good results when thrown down from solution in ammonium sulphide. Platinum is readily estimated quantitatively by electrolyzing its solution in hydrochloric acid or ammonium oxalate with a current of half the above strength. The author gives the results of the electrolytic separation of iron from cobalt, nickel, zinc and uranium, of zinc from chromium and uranium, of cobalt from chromium, all of which are accurate.—*Ber. Berl. Chem. Ges.*, xvii, 2467, Nov. 1884. G. F. B.

3. *On the Specific Gravity of Monohydrated Sulphuric acid.*—MENDELEJEFF has reviewed all the determinations which have been made of the specific gravity of sulphuric acid monohydrate, and concludes that those of Marignac in 1853, giving 1·8372, of Kohlrausch in 1876 giving 1·8373, of Schertel in 1882 giving 1·8371, which agree with those made by him in 1884 giving 1·8371, all at 15°/4° in vacuo, are the more probably correct, since they agree to 0·0002.—*Ber. Berl. Chem. Ges.*, xvii, 2536, Nov. 1884. G. F. B.

4. *On Octosulphates.*—WEBER has succeeded in preparing a series of sulphates which are perfectly definite and which contain a very large proportion of the acid radical. For the preparation of the potassium salt, one leg of a U tube is filled with pure sulphuric oxide and the other with perfectly dry potassium sulphate. The tube is then sealed, inverted and slowly heated in a water bath. Combination takes place and two layers of liquid appear in the tube. By slow cooling, beautiful well-formed crystals separate from the lower layer, apparently quadratic in form. The tube is now opened and the still liquid oxide poured off. It is then again sealed, heated to fuse the crystals, allowed to cool and the liquid oxide again poured off; the operation being repeated till the crystals are free from oxide. The composition of these crystals was determined by synthesis, a weighed quantity of potassium sulphate being used. When 0·3455 grm. K_2SO_4 was used, the resulting compound weighed 1·488 grams; showing that 76·78 per cent. of it was sulphuric oxide. This corresponds to the formula $K_2O.(SO_3)_8$ or $K_2SO_4.(SO_3)_7$. Similar sulphates were obtained with rubidium, cæsium, ammonium and thallium. Sodium, lithium and silver did not appear to form them, at least not readily.—*Ber. Berl. Chem. Ges.*, xvii, 2497, Nov. 1884. G. F. B.

5. *On the Separation of Arsenic from Tin and Antimony.*—At the suggestion of Classen, HUFSCHMIDT has made a series of experiments on the separation of arsenic from antimony and tin by distillation of its chloride. He finds that if the arsenical solution is brought to about 250 c.c. by the addition of concentrated hydrochloric acid and then completely saturated with HCl gas and distilled in a current of this gas, the volatility of the arsenous chloride is such that nearly the whole of it is removed before the first drops of distillate enter the receiver. After about 50 c.c. of the distillate has collected in the receiver, no trace of arsenic can be detected in the subsequent portions. To condense this very volatile body a Woulfe's bottle of about 900 c.c. is used as a receiver, containing from 300 to 400 c.c. of water or of potassium hydrate solution of sp. gr. 1·1 to 1·2. The results of the separations effected by this method which are given seem to be entirely satisfactory. —*Ber. Berl. Chem. Ges.*, xvii, 2245, Oct. 1884. G. F. B.

6. *On the Purification of Arseniferous Zinc.*—L'HÔTE has examined for arsenic the commercial zincs found in France, and finds, for one kilogram of sheet zinc, Vieille-Montagne, 36, 30 and 20 milligrams arsenic in three samples, Harfleur 10·5 mgrms., and Company Asturienne 26 milligrams. The slab zinc, Vieille-Montagne and Silesia, gave only traces. In order to purify this arseniferous zinc the author recommends to project into the melted metal one to one and a half per cent of anhydrous magnesium chloride. On stirring, white fumes of zinc chloride mixed with arsenous chloride are evolved. If now the metal be poured into water to granulate it, the zinc obtained is free from arsenic and is readily attackable by one-tenth sulphuric acid. The same process will free zinc from antimony.—*Ann. Chim. Phys.*, VI, iii, 141, Sept. 1884. G. F. B.

7. *On Perseite, a new Sugar.*—MUNTZ and MARCANO have described a new sugar obtained from the seeds of the *Laurus persea*, a tree growing in the tropics. This sugar had been observed by Avequin in 1831, and by Melsens later; but it was by them supposed to be mannite. It is extracted by boiling alcohol from which it crystallizes on cooling. Analysis gives it the formula $C_{12}H_{14}O_{12}$, isomeric with mannite. Its point of fusion is 183·5°–184°, while that of mannite is 20° lower. It is very soluble in hot, less so in cold water. Even in concentrated solution it has no action in the polarimeter. On adding borax however to a 4 per cent solution it gave a rotation to the right of 0·55°. It does not reduce copper solutions and is not fermentable. Boiling nitric acid converts it into oxalic acid, without the production of mucic acid. A mixture of strong nitric and sulphuric acids gives a trinitro-perseite which detonates violently by a blow and spontaneously decomposes.—*Ann. Chim. Phys.*, VI, iii, 179, Oct. 1884. G. F. B.

8. *Synthesis of a Coloring matter resembling that of Litmus.*—TRAUB and HOCK have shown that when resorcin is heated with a small quantity of sodium nitrite and some water to a tempera-

ture not exceeding 150°, a deep blue color is developed, which has in its properties a very close resemblance to that of litmus. It readily becomes red on the addition of acids and is very sensitive as an indicator for titrition. In alkali-solution it shows a broad band in its spectrum near the line D which shades off toward E. In acid solution, it cuts off the more refrangible portions of the spectrum.—*Ber. Berl. Chem. Ges.*, xvii, 2615. G. F. B.

9. *Use of the induction Spark in Spectrum Analysis.*—M. DEMARÇAY has modified the method of M. Lecoq de Boisbaudran by employing an induction coil made of comparatively large and short wire. By means of this induction coil atmospheric lines of the second order are not obtained and rarely the nebulous bands of azote or the lines of the electrodes. The spark has sufficiently high temperature to give the spectra of all the known elements without the employment of strong currents. The coil employed by M. Demarçay under the action of 6 to 9 bichromate cells (zincs $0^{m}{\cdot}10$ to $0^{m}{\cdot}16$) coupled 2 or 3 for quantity and 3 for tension gave a spark of 5^{mm}. The inner diameter of the bobbin was $0^{m}{\cdot}115$ and its length was $0^{m}{\cdot}23$. The diameter of the wire of the primary was 1^{mm}, it weighed $1^{kg}{\cdot}320$ and was coiled in two layers. The diameter of the wire of the secondary coil was also 1^{mm} and it weighed $3^{kg}{\cdot}400$. The bundle of iron wires was 27^{mm} in diameter and weighed 680^{gr}. The condenser was three times the dimensions usually employed with induction coils of this size. —*Comptes Rendus*, Dec. 8, 1884, p. 1022. J. T.

10. *Effect of the Magnetic field upon Light.*—CORNU in a mathematical paper gives his reasons for believing that a double refraction of a peculiar nature exists in a magnetic field in a direction at right angles to the lines of force. This double refraction has not yet been observed; but Cornu shows that the quantity to be observed is of the order of dimension of a wave length and ought therefore to be detected with the powerful means now at our command.—*Comptes Rendus*, Dec. 15, 1884. J. T.

11. *A new Galvanometer.*—J. ROSENTHAL describes a new form of galvanometer which is said to have great range and great sensitiveness, and is made by Edelmann, of Munich, for about forty dollars. Its novelty consists in the needle which is a horse-shoe magnet suspended by a long fiber attached to its neutral point. The poles of the magnet are provided with horizontal pole pieces, which are quadrantal arcs of a circle the center of which lies in the axis of suspension of the horse-shoe. These pole pieces can play within the axis of two galvanometer bobbins placed on opposite sides of the vertical plane of the horse-shoe when the plane coincides with the magnetic meridian. When an electric current passes through the coils, these pole pieces are respectively drawn in and repelled by the two bobbins. In this way the poles of the magnet can be brought very near the center of the coils. Rosenthal gives the results of various measurements which he has made to test the sensitiveness of this instrument. Without compensation by an exterior magnet $0{\cdot}1^{mm}$ deflection corres-

ponds at a scale distance of 2700^{mm} to $\frac{54}{10^{10}}$ of an ampère. With compensating magnet $0{\cdot}1^{mm}$ deflection to $\frac{12}{10^{10}}$ of an ampère. A difference of 10° C. between the junctions of one german silver and iron thermo-element gives a deflection of 120^{mm} through 1000 ohms resistance at a scale distance of 2700^{mm}.—*Annalen der Physik und Chemie*, No. 12, 1884, pp. 677–686. J. T.

12. *Electrical resistance of microphone contacts during movement.*—The theory of the action of the microphone is still little understood. Otto Boekman, in his paper, gives the results of many measurements upon polished carbon contacts with different current strengths, and with varying pressure upon the contacts. The results are expressed graphically, and the author concludes that the resistance of polished carbon contacts, under constant pressure and with constant current strengths, is smaller during movement than during rest. After cessation of the movement the contacts return to their original resistance. The difference between the resistance of movement, and that of rest is greater, the greater the original resistance—or which is the same thing—the less the original pressure. The resistance of movement with constant pressure and decreasing strength of current increases and returns to its original amount, after cessation of movement. The resistance decreases with diminished movement and diminished strength of tone of the tuning fork interrupter, the pressure and the strength of the electrical current remaining the same. The resistance during the movement is with same strength of tone and strength of current not dependent upon the number of vibrations, which the movement indicates—it is also independent of the pitch.—*Ann. Phys. Chem.*, No. 12, 1884, pp. 651–665. J. T.

13. *Resistance of the Siemens Mercury unit.*—H. Wild communicates in detail the results of his new measurements of the mercury unit and obtains the value 1. S. E.=0·94315 ohm, and therefore concludes that $106{\cdot}027^{cm}$ of mercury, one square millimeter in section at 0° C., represents the resistance of an ohm.—*Annalen der Physik und Chemie*, No. 12, 1884, pp. 665–677. J. T.

II. Geology and Natural History.

1. *A Scorpion from the Upper Silurian.* — A fossil Scorpion has been found in the Upper Silurian (Ludlow) of Gotland, Sweden, and named by MM. Torell and Lindström, *Palæophonus nuncius*. The specimen is well preserved and shows clearly the cephalothorax, the abdomen with seven dorsal plates, and the tail, consisting of six segments, the last pointed to form the poison-dart. The sculpture of the surface consists of tubercles and longitudinal ridges, and is exactly as in recent scorpions. One of the stigmata is visible on the right side, proving that the animal respired air.

Further, a fossil scorpion was obtained last year by Dr.

Hunter, of Carluke, from the Upper Ludlow beds of Lesmahago, in Lanarkshire. Owing to the ill health of Mr. B. N. Peach, to whom it was sent, it was not studied until a photograph of the Swedish species was received from Dr. Lindström. The two are closely allied, and may be of the same species.—*Ann. and Mag. Nat. Hist.*, January, 1885, p. 76, citing the note on the Swedish Scorpion from *Comptes Rendus*, December 1, 1884, p. 984.

2. *Dinocerata, a Monograph of an Extinct Order of Gigantic Mammals;* by OTHNIEL CHARLES MARSH. 56 plates and 200 woodcuts. i–xviii and 237 pp. 4to. Washington, 1884. *United States Geological Survey, Volume X.* Advance copy issued with the permission of the Director.—A review of this important memoir will appear in the next number of this Journal.

3. *Names of extinct Reptiles;* by O. C. MARSH.—The name *Amphisaurus*, given by the writer to a genus of Triassic reptiles, proves to be pre-occupied, and may be replaced by *Anchisaurus*. The name of the family would then be *Anchisauridæ*. *Camptonotus*, applied to a genus of Jurassic reptiles, has also been used, and *Camptosaurus* may be substituted. *Limnophis*, already in use, may be replaced by *Lestophis*.

4. *Botanical Necrology for* 1884.—The list should begin with the name of a devotee to botany who died some time in the year 1883, namely:

AUGUSTUS FENDLER. After Dr. Engelmann's death, the beginning of a notice of Mr. Fendler was found upon his table, from which it was learned that he had died at Trinidad, some time previous. Inquiries sent to the Port of Spain, where he had for several years resided, remain unanswered. An autobiographical account which he addressed to a correspondent (and which, with some of his letters, we hope will before long be printed), enables us to state that Mr. Fendler was born at Gumbinnen, on the easternmost borders of Prussia, January 10, 1813, lost his father in infancy, was sent to the gymnasium of the town when twelve years old, but was at sixteen apprenticed to the town clerk, where, perhaps, he perfected the neat and clear hand-writing with which his correspondents are familiar. Having a fondness for mathematics and chemistry, he obtained, in 1834, upon examination, a nomination to the Royal Polytechnic School at Berlin, but relinquished it after a year on account of delicate health; in 1836 he came from Bremen to Baltimore, "with a couple of dollars in his pocket," worked in a tan-yard in Philadelphia, then in a lamp factory in New York; in 1838, traveled in the most economical way to St. Louis, which required thirty days, and was employed by a lamp-maker who made "spirit-gas" for lighting public houses, coal-gas being then unknown so far west. Soon after he made his way to New Orleans and to Texas, where he was witness to the ravages of yellow fever in the summer and fall of 1839; he returned to Illinois, broken in health and empty in purse, taught school for some time, then, the spirit of wandering and of solitude coming strongly upon him, he took possession of an uninhabited

island in the Missouri River, about 300 miles above St. Louis, where he enjoyed a hermit's life for six months, and until a great spring rise of the river threatened to sweep away his cabin, when he took to his canoe, and dropped down the stream among the floating logs and masses of ice. In 1844 he returned to Old Prussia on a visit, at Königsberg made the acquaintance of Ernst Meyer, the professor of Botany, and learned from him—what he would have been most glad to know before—that dried specimens of plants for the herbarium might be disposed of at a reasonable price. Returning to St. Louis, he began to collect plants in this view, took the specimens to Dr. Engelmann, who gave him botanical assistance and encouragement. In 1846 Dr. Engelmann and the writer of this notice obtained permission for the transportation of Mr. Fendler and his luggage along with the body of U. S. troops which took possession of Santa Fé, New Mexico; there he remained for about a year, and made his well-known New Mexican collection, the first fruits of the botany of that interesting district. In 1849, he attempted another western botanical expedition, this time with Salt Lake in view. But on the plains he lost all his drying paper in a flood of the Little Blue River, and he returned to St. Louis, to find that all his collections, books, journals and other possessions had been burnt in the great conflagration which had just devastated that city. He now sought a different climate, and, at the approach of winter, went to the Isthmus of Panama for four months, made at Chagres an interesting botanical collection, returned by way of New Orleans to Arkansas, and to Memphis on the Tennessee side of the river, where for three years he carried on the camphene-light business, botanizing in the vicinity when he could. In 1854, the introduction of gas having made his occupation unprofitable, and a craving for new scenes being strong upon him, he sailed for La Guayra, went up to Caraccas and thence to Colonia Tovar, 6,500 feet above the sea, built his cabin on the mountain side, where he lived four or five years and amassed his large and fine Venezulean collections of dried plants, so well known in the principal herbaria of the world. His principal companions were his thermometer and barometer, and his careful meteorological observations were published by the Smithsonian Institution, in the report of the year 1857. Returning to Missouri, in 1864, he bought some wild land at Allenton, cultivated and lived on it for seven years (except one winter passed in the herbarium at Cambridge), having the companionship and assistance of a half-brother who had joined him, and whom, being rather feeble-minded, he took care of for the rest of his life. In 1871, having sold his place in Missouri, he returned again to Prussia, intending to remain in his native country. But he soon longed for the New World, to which he returned in 1873; he settled in Wilmington, Delaware, where, having the botanical companionship of Mr. Canby, he again interested himself in his favorite pursuits,—but now much more in speculative physics. For years

the thoughts of his solitary hours had turned upon the cause of gravitation and its probable connexion with other forces, and while at Wilmington he wrote (and unhappily printed at his own expense) a thin octavo volume, entitled "The Mechanism of the Universe." Repeated attacks of acute rheumatism constrained him to seek again a tropical climate, this time the island of Trinidad. He and his brother landed at the Port of Spain in June, 1877, where he passed the remainder of his days, living mainly on the products of the small plot of land which he purchased, renewing his old interest and activity in making botanical observations and collections, especially among the Ferns, of which he sent to Professor Eaton collections worthy of his better days. But, having exhausted in this respect the field within his immediate reach, and lost the vigor needed for laborious excursions, little had been heard of him for the past few years, and it is only indirectly that the fact of his death has been made known to us.

It is needless to say that Fendler was a quick and keen observer and an admirable collector. He had much literary taste, and had formed a very good literary style in English, as his descriptive letters show. He was excessively diffident and shy, but courteous and most amiable, gentle, and delicately refined. Many species of his own discovery commemorate his name, as also a well-marked genus, a Saxifragaceous shrub, which is winning its way into ornamental cultivation.

Fendler's death probably did not long precede that of his patron and friend,

George Engelmann, whose lamented decease, on the fourth of February, 1883, at the age of 75, was announced in this Journal at the time; and whose biography is given in the July number. There is also an interesting memorial in Science, April 4, by his friend and associate Professor Sargent.

Samuel Botsford Buckley died at Austin, Texas, February 18, 1883, in the 75th year of his age. He was born in Yates Co., New York, near Pen Yan, on the 9th of May, 1809, was educated at Wesleyan University, Middletown, Conn., became for some time a teacher, at first in Illinois, where his earliest botanical collections were made, then in Alabama and some of the neighboring States, and was one of the earliest explorers of our time in the southwestern portion of the Appalachian Mountains. His first and probably his best paper, describing some new species of this region, was published in this Journal in 1843, at the same time with the characters of the remarkable genus which botanically commemorates him, viz: the *Buckleya distichophylla* of Torrey, a peculiar and graceful Santalaceous shrub, of which Mr. Buckley first discovered the flowers and fruit, Nuttall before him having found only the foliage. In later years Mr. Buckley resided mainly in Texas, where he was appointed State Geologist in 1866; but he was the naturalist of the State Survey much earlier. Many new species and some genera were published by him in the years 1860–62, in the Proceedings of the Academy of Natural Sciences at Philadelphia. His zeal in botany and his knowledge

of plants of the Southern States in their native habitats were great; his opportunities and training for doing descriptive botanical work were not of the best. It is said that he "was several years engaged in writing a work on the trees and shrubs of America, which is unfinished." An appropriate biographical notice of Mr. Buckley, by S. H. Wright, is in the eleventh volume of the Bulletin of the Torrey Botanical Club.

JOHN WILLIAMSON, of Louisville, Kentucky, died June 17, 1884,—a young man, of Scottish birth, an amateur botanist, chiefly in Ferns; the author of the Ferns of Kentucky, in two editions, illustrated by graceful and characteristic figures printed directly from the author's etchings, which are wonderfully good. We need here only refer to two memorials of this gifted artist and pteridologist, from most capable and loving hands, one by Mr. G. E. Davenport in the Botanical Gazette, ix, 122; the other by J. H. R. in the Bulletin of the Torrey Botanical Club, xi, 104.

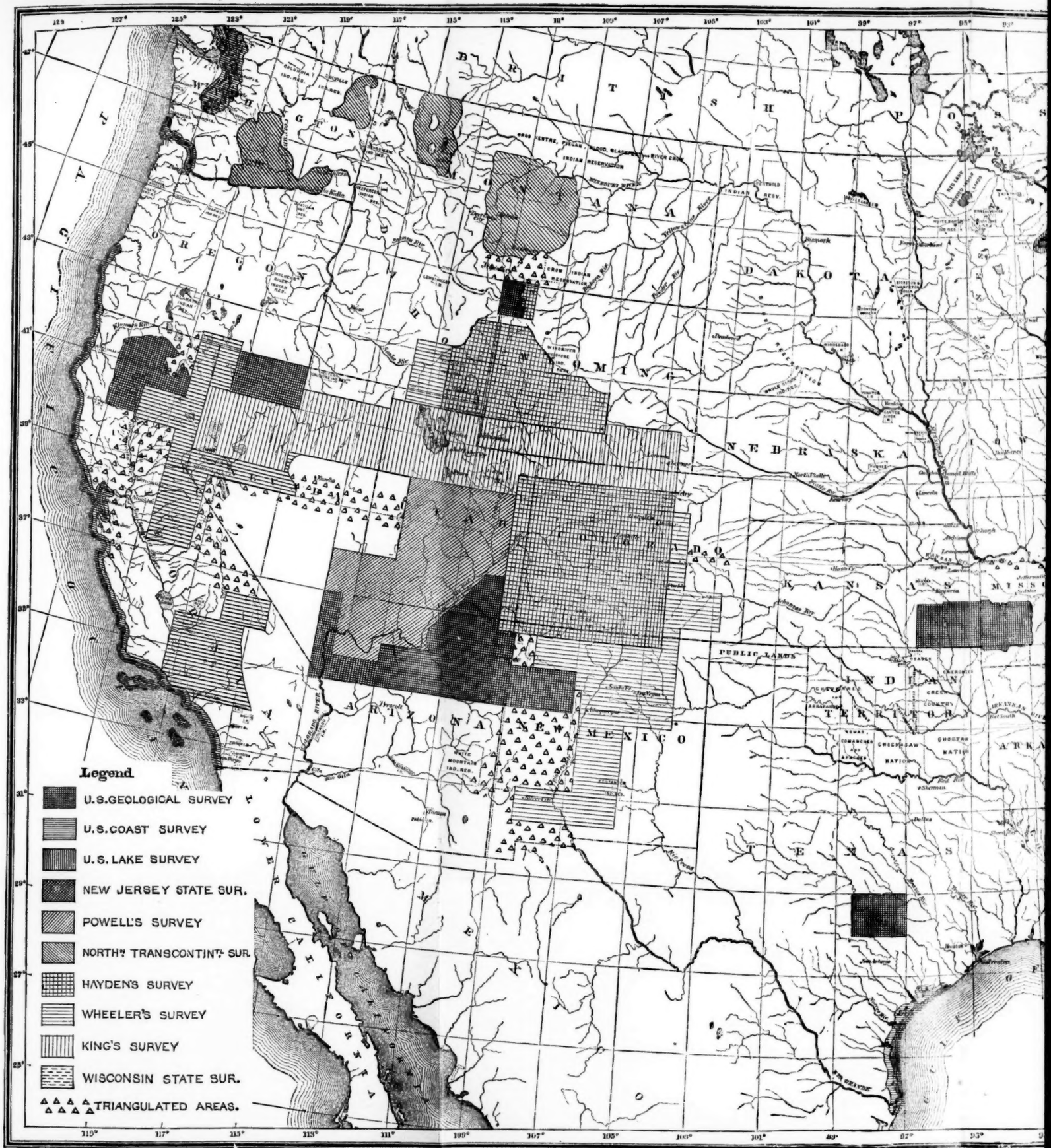
Of Botanists in Europe the principal losses in 1884 are those of JOHN HUTTON BALFOUR, one of the founders of the Edinburgh Botanical Society in 1836, an eminent teacher and a man of various learning; Professor of Botany first at Glasgow, but since 1846 at Edinburgh, his native town, where, after a few years of superannuation, he died, February 11, 1884, in the 76th year of his age.

HEINRICH ROBERT GŒPPERT, Professor of Botany at Breslau, eminent as a teacher and in Paleo-botany, died May 18, 1884, in the 84th year of his age.

GEORGE BENTHAM, the greatest descriptive and taxonomical botanist since DeCandolle and Brown, died Sept. 20, close upon his 84th birthday. A memorial finds a place in the present number of this Journal, p. 103. A. G.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The late Henry Watts, F.R.S., F.C.S.*—A recent number of the Chemical News (Dec. 5, 1884), states that in November last, at a meeting held at the Royal Institution, a committee was formed to collect funds for the benefit of the wife and children of the late Mr. Henry Watts. It appears that notwithstanding his remarkable industry, and the many contributions which he made to science, the money return for his labors was small and only sufficed for daily wants, and now at his death his invalid wife and ten children find themselves with almost nothing to depend upon. The income available amounts to the pitiful sum of £100 a year, and only two of the children are in a position to render assistance. In view of the great benefit which every chemist has received from the almost unremunerated labors of Mr. Watts, notably from his great Dictionary of Chemistry, the appeal which the committee now makes to chemists at home and abroad should receive a prompt and liberal response. All contributions, whether large or small, will be welcome. Subscriptions may be sent to Dr. E. Waller, of New York, (4th Avenue and 49th St.).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WISCONSIN STATE SUR.
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PUBLIC LANDS
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